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COMMUNICATIONS

ON THE EYE OF THE OX AND ITS INTERNAL BLOODVESSELS*

BY

PRIESTLEY SMITH

BIRMINGHAM

A FEW words in the first place on the original purpose of this investigation.

We know that the blood-streams that pass through the eye fall in pressure as they do so: their exit pressure is considerably lower than their entrance pressure. We do *not* know how the fall is distributed: how much of it occurs in the arteries, how much in the capillaries, how much in the veins. If we did, we could better understand certain processes whose nature is still questioned, e.g., the secretion of the intraocular fluid by certain vessels, and its absorption by others. Now, if it were possible to measure and count the channels through which the blood has to pass at different parts of its course, one could, with the help of physical principles, learn in some degree how the fall is distributed—one could construct a pressure line for the intraocular circulation. That is what I desired to do.

The initial steps of the enquiry were published in this Journal several years ago (BRITISH JOURNAL OF OPHTHALMOLOGY, 1917, pp. 48 and 657; 1918, p. 257). The present paper exhibits some of the anatomical material collected since that time. It leaves the

*Many of the preparations reproduced at the end of this article were shown under the microscope and on the screen to the Section of Ophthalmology of the Royal Society of Medicine on Nov. 12, 1920, and to the Midland Ophthalmological Society at an earlier date.

question of blood-pressure aside for the moment. Many counts and measurements have been made, but these, and the inferences they suggest, must be dealt with in a separate article.

Leber's unrivalled description of the bloodvessels of the eye[1] was consulted on every point, but it does not afford sufficient data for the purpose. One could not work out the subject on human eyes; such material fresh and healthy is not to be had. I turned, therefore, to the albino rabbit, the absence of uveal pigment offering evident advantage. The results have, I think, some interest.

Rabbit No. 1 was killed by chloroform. It was then suspended by the hind feet; pressure was made on the abdomen; the ears and conjunctiva became visibly congested. The neck was then tightly ligatured, and severed between ligature and body, and the head was placed in normal saline with formalin 5 per cent. These steps were designed to fill the intraocular vessels with blood and to fix them in that state. They failed. Excised and opened a week later the eyes were internally almost bloodless. Only the larger veins of the choroid and ciliary processes contained broken blood-columns; the other vessels were nearly empty. Had they failed to fill during the external congestion, or had they emptied themselves later? A second observation answered that question.

Rabbit No. 2, without disturbance of any kind, was viewed ophthalmoscopically with regard to the natural tint of the fundus-reflex. It was then killed by coal gas instead of chloroform, to relax the arteries, and suspended as in the first case. A long elastic cord was wound round the body from thighs to shoulders, with a pad on the abdomen. Intense congestion of ears and conjunctiva, with protrusion of the eyes, immediately ensued. *The fundus tint, viewed ophthalmoscopically, was no deeper than in the normal living eye, perhaps even a little paler.* The left cornea was now punctured with a cataract needle. The aqueous escaped with abnormal force and the iris instantly assumed a deeper colour. The fundus-tint was now found to be much deeper than in the unpunctured eye. The animal was suspended in a jar with head and shoulders immersed in saline-formalin solution, the compressive cord being left in place. Examined ten days later the *unpunctured eye* was found to be nearly as bloodless as those of rabbit No. 1, whereas the *punctured eye* showed intense injection of the uveal tract and retina.

In this latter experiment blood was driven with great force into the orbital vessels, as proved by the protrusion of the eyeballs, yet it failed to fill the intraocular vessels until the cornea was punctured. Why so? Evidently its entrance was prevented by high pressure in the chambers, caused no doubt by pressure on the sclera from without. The forcible afflux of blood to the head, chiefly venous blood moving in the wrong direction, would distend the large orbital veins and drive the eyes outwards, raising thereby their internal pressure, before it could fill the internal vessels. When further displacement of the eyeballs became impossible the whole contents of the orbit, both within and without the eye, would stand at a uniform high pressure and the blood would cease to move, until the puncture of the cornea suddenly lowered the chamber pressure and allowed it to rush in.

This method of injecting the intraocular bloodvessels for the microscope, viz., killing by an anaesthetic, compression of the trunk, puncture of the cornea, and immersion in a fixing fluid, gave some interesting preparations. Further trial, using less compression, would probably have given better ones; hence this description of it. I do not know whether others have used it. I did not employ it further because more valuable material came into my possession.

For all my best material I am indebted to Mr. Frederick C. Lowe of Wednesbury. Mr. Lowe is an expert with the microscope and camera, not professionally, but for love of the work. He has exceptional skill in injecting minute blood-vessels, especially the intraocular vessels of animals of several kinds. Happening to hear of my efforts he kindly offered me his help, and he has given it most

amply and generously. As regards injection and photography, the preparations here reproduced are his work. The section cutting was done by myself, with assistance. Some statement of the methods used is probably desirable.

Injecting. The following details are given by Mr. Lowe. The eye is excised, together with muscles, nerve and fat, without dragging, immediately after the animal is killed, and injected as soon as possible. The canula is inserted into the larger of the two arteries found by the side of the nerve; the other is tied. The vessels are washed out with warm normal saline under a pressure of 40 mm. Hg, the eye being under warm water. The reservoir holding the injection mass and the water containing the eye are then gradually heated to about 100° F. The reservoir is connected on the one hand with the canula, air being excluded from the tube, and on the other with a pump, air-chamber, and U-shaped mercurial manometer, and the injection is begun under a pressure of 40 or 50 mm. Hg. The cornea is usually punctured. When the mass flows freely from the cut veins these are closed with clips. The pressure is then raised gradually to 100 mm. Hg. (of late to 80 by preference) and kept at that height for 10 or 15 minutes. When successfully injected the eye feels elastic, not hard, between the thumb and finger (the pressure in the vessels is largely borne by their own walls, not fully transmitted to the fluid in the chambers); if the eye feels hard a vessel has ruptured; the aqueous is clear not clouded, the external vessels are visibly injected. The injection being completed, the eye is cooled with cold water, time being allowed for the injected mass to solidify. Canula and clips are then removed and the eye is placed in 3 per cent. formalin solution.

The injection-fluid, until lately, was usually a suspension of precipitated lead chromate in a gelatin solution; of late, finely ground vermilion similarly suspended and cleared of coarse granules by filtration has given excellent results.

Removal of pigment epithelium. After the eye is opened the ciliary processes are denuded of epithelium by letting a fine jet of water play forcibly upon them. The outer surface of the choroid is treated in like manner and by supplementary brushing with a camel-hair pencil.

Embedding, section-cutting and mounting. I used a non-alcoholic method for three reasons. First, because I was familiar with no other. Second, because I feared the effect of dehydration on the gelatinous casts of the vessels. And third — perhaps the only good one of the three — because alcohol, at the time when I began, was not obtainable, whereas I possessed a little glycerin.

The tissue to be cut is laid in a small china saucer and covered with melted "water jelly"—(gelatin, 1 part by weight; water containing 1 per cent. of carbolic acid, 7 parts). When firmly set, the slab so formed is removed from the saucer and placed in 1 per cent. formalin solution to render it incapable of subsequent melting. Suitable slices are cut from it with scissors or razor and these are sectioned in the usual way on the freezing microtome, in gum. Each section is floated on to a slide under water, drained, and mounted in glycerin jelly — (glycerin, 1 part; water-jelly as described above, 2 parts.) The "water jelly" before being used must contain no formalin, or it will not melt, and no glycerin or it will not freeze.

The illustrations on special paper are reproductions, by the Arthur Cox Illustrating Co., of micro-photographs by Mr. Lowe. Those in the text are from hand drawings made with the Leitz drawing-prism.

The Eye of the Ox

FIG. A shows certain differences between the ox's eye and the human eye:—*(a)* The axis of the eyeball diverges widely from the median line of the head. With the help of a folding two-foot rule I judged the angle to be about 45°; using a goniometer designed for the purpose Lindsay Johnson[2] estimated it, probably more correctly, to be 52°. The two eyes, therefore, diverge at an angle of more than 90°. The optic nerve joins the eye in its temporal hemisphere, not in the nasal as in man. The difference evidently lies in the position of the eyeballs rather than in that of the nerves.

In spite of the divergence the ox has a certain power of binocular vision and uses it when he wishes to see his best. Walk quietly across a field where cattle are grazing, and many of them will be content to regard you with a single eye; make an unusual noise or take a lively dog with you, and they will turn so as to watch the intruder with both. This implies that the ox sees well with a peripheral part of the retina and by means of a visual axis differing widely from the geometric axis of the lens. Other evidence to the same effect will appear later.

Because of the divergence the ox sees further round than we do. With his two eyes he commands, I think, at least three quarters of a circle in the horizontal plane. Some animals certainly command

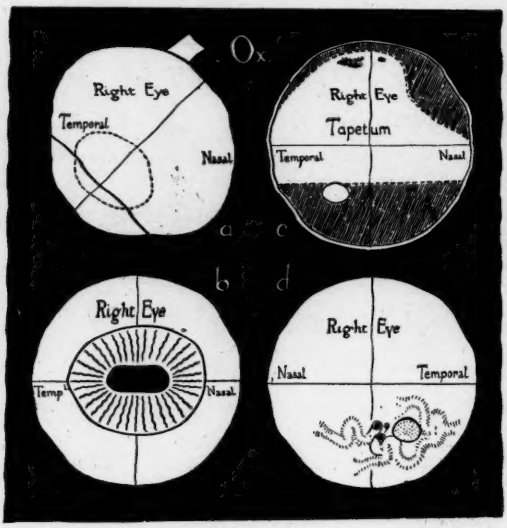

FIG. A.

a still wider field. I tested a sheep on this point. While she lay resting on the grass I approached slowly from behind, trying to remain unseen. But whatever line I took I could always see one or other of her eyes: when I stepped a little to one side to get this eye out of sight, she moved her head a little and I saw the other; when one of her ears hid the effective eye, she lowered that ear, but not the other. She kept an eye on me with very little trouble. Different animals differ much in this respect. Safety seems to explain the difference. Animals that live by hunting others, e.g. lions, wolves, eagles, owls, have little need for backward vision and their eyes are directed chiefly forwards; while those in danger from

beasts or birds of prey can keep a look-out further round (see Lindsay Johnson's table of divergence in mammals). Oxen and sheep in their wild state are among the hunted.

(b) Viewing the eye in the line of its axis one sees that the cornea is oval, the broader end being towards the nose, the narrower towards the temple; also that the pupil is oblong, its long diameter corresponding with that of the cornea. The long diameter of the pupil is about parallel with the lower border of the jaw, and about horizontal when the neck is in line with the back; when the animal is grazing it is directed towards the ground a little in advance of the nose. These adaptations help to extend the field of vision laterally. The ox, unlike the rabbit for example, whose cornea and pupil are round, has no need to keep a look-out upwards.

(c) Viewing the posterior hemisphere from within, we see that the centre of the papilla lies about 10 mm. below the horizontal meridian and about 7 mm. to the outer side of the vertical.

The most conspicuous feature, however, is the tapetum lucidum, a shining area of resplendent peacock blue occupying a large part of the choroidal surface in the upper hemisphere, and extending in the lower down to the level of the papilla and almost to the ora serrata on each side. Its colour is due to "interference" (Hess[3]), this part of the choroid being lined with a fibrous tissue which throws back certain rays of the spectrum but not the others. Under the microscope thin sections of the tapetal tissue appear highly coloured when lighted in certain directions from above, but colourless and transparent when lighted from below. In its normal condition it strongly reflects certain coloured rays and hides the underlying pigment cells, but it is not opaque in the ordinary sense.

The tapetal area corresponds with the most valuable part of the ox's visual field: the part that pictures the ground and the objects near it, not the sky. The broader temporal portion looks chiefly forwards and downwards, the narrower nasal portion chiefly backwards. It certainly affords aid to vision. How does it act? Helmholtz suggested that by reflecting incident rays back along their paths through the retina it gives additional stimulus to the retinal elements. This accords with the fact that animals active in the dusk have commonly a tapetum lucidum. But the explanation is incomplete, for some other animals have it also. And what of the special colour, which differs much in different species? Does the tapetum so stimulate certain colour-sensations rather than others as to aid the animal in distinguishing objects of those colours from their surroundings, e.g., one kind of herbage from another in the case of the ox, an animal from ground or grass in the case of the carnivora? Or is the colour a by-product without physiological significance?

(d) Looking at the eyeball from behind, one sees the nerve attached to the lower outer quadrant, and near to it the main

trunks of the posterior ciliary arteries passing from the inner side of the nerve to become attached to the outer surface of the sclera, on both sides of the nerve.

FIG. B, drawn from measurements of several eyes, represents the anterior part of the eye incised radially and laid out flat, viewed from behind. It is given to show the eccentricity of the ciliary body. The tips of the processes lie in a circle concentric with the lens, whereas the ora serrata, the posterior boundary of the ciliary body, comes further forward at the nasal side than elsewhere. Its distance from the tips of the processes here is about 5.5 mm., on the temporal side 10 mm., above about 11 mm., and below 8 mm. Between the ora serrata and the corneal margin as seen externally, the want of concentricity is greater still. A needle passed through

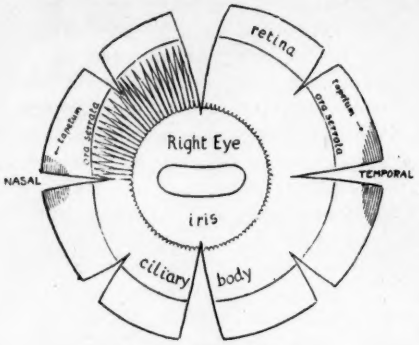

FIG. B. Natural size.

the ora serrata from within emerges on the nasal side at about 2 mm. from the limbus, on the temporal at 5 or 6, above at 12, and below at 11 mm. The angle of the anterior chamber does not follow the contour of the cornea; it is nearly circular, for the opaque sclera overhangs it widely above and below, and hardly at all at the sides.

The advance of the retina on the nasal side, aided by the shape of the cornea and pupil, extends the field of vision in the backward-outward direction. A similar advance on the temporal side would be useless, for in the ox, as in man, the field is limited in the inward-forward direction by the nose. At both sides, be it noted, the tapetum reaches forward on the horizontal meridian almost to the limit of the retina, so that the animal may not only see, but see well, as far round as possible.

Orientation of an excised ox eye is easy. Turn the cornea towards yourself with the long diameter horizontal, and with the optic nerve below the horizontal meridian. Now, if the broad end of the cornea is to your right, you have the ox's right eye, if to

your left, his left. After the eye is bisected, the tapetum and the nerve will distinguish the upper hemisphere from the lower, or the temporal from the nasal. In an anterior segment, the lie of the pupil will show the horizontal meridian, and the breadth of the ciliary body will distinguish the temporal side from the nasal.

THE BLOODVESSELS.

The posterior ciliary arteries.—FIG. 1 is from a section about 10 mm. behind the eyeball. It shows the two main arteries that supply the interior of the eye lying to the inner side of the optic nerve. One of these comes from the internal carotid, the other indirectly from the external (Leber). Near to the eye they communicate freely with each other, sometimes uniting for a few millimetres to form a single trunk. Fluid injected into either escapes immediately and copiously through the other unless this latter be tied; if it be tied, there is little or no escape from any vessel until, after about fifteen seconds, a flow from the cut vortex veins begins (Lowe). This proves two things: first, that if there be a difference of pressure in the two trunks, it is neutralized before the blood reaches the eye; and, second, that these two trunks convey little, if any, blood to parts outside the eye.

Near to the eyeball the two arteries separate, one of them passing round below the nerve to the temporal side. They give off many branches here. On reaching the sclera, they traverse its outer surface tortuously for some distance before they disappear; they groove it, are bound firmly to it, and send many branches into it. But what look like single trunks here prove, when cut across, to be groups of vessels contained in wide fibrous tunnels. The largest lie on a level with the nerve on its nasal and temporal sides.

FIG. 2. A thin layer has been sliced away from the back of the sclera in the region of the nerve. Many small vessels are divided just above and below the nerve, a group of larger ones a little higher up; the largest enter the sclera outside the limits of the picture; none pass deeply into it here. The fissure for the retinal vessels begins to appear; these vessels enter the nerve through the sclera, not behind the eyeball as in man.

FIG. 3 is from the same eye. The section is parallel with the last, and deeper in the wall of the eye. At this depth the sclera, which is more than 2 mm. thick here, shows hardly any vessels. The retinal vessels are seen entering the nerve.

FIG. 4, again from the same eye, shows a section almost on a level with the papilla. Above, it passes obliquely out of the sclera into the outer layer of the choroid, and exposes some of the small choroidal arteries.

FIG. 4 A shows the retinal vessels emerging from the papilla—somewhat displaced by the removal of the retina. The papilla is

partly hidden by the overhanging choroid. Above it the tapetal area is seen, below it the non-tapetal.

To see the multitudinous vessels that enter the sclera near to the optic nerve, one must cut perpendicularly to the surface, not tangentially. In a rectangular piece measuring 20 mm. horizontally by 15 mm. vertically and having the optic nerve at its centre, I found nine vessels in the upper cut edge, nine in the temporal, nine in the nasal, and three in the lower, nearly all arteries, and all near to the outer surface.

FIG. 5 shows a group of arteries in the sclera 10 to 15 mm. behind the equator and below the horizontal meridian. They are still near to the outer surface. The sections are parallel with the equator. The narrower strip is the anterior of the two. Small branches pass steeply through the sclera to the choroid.

FIG. 6. These sections are anterior to the foregoing; the broader lies just in front of the equator, the narrower a few millimetres further forward. They show the long posterior ciliary arteries. In the human eye a single such artery on each side runs forward between sclera and choroid on the horizontal meridian, and bifurcates on reaching the ciliary body. In the ox, the chief artery on each side, after sending many branches to the choroid, bifurcates behind the equator while still near to the outer surface of the sclera, and so forms the twin vessels here seen. These, running forward close together, one above the other, and still giving off branches to the choroid, reach the inner surface of the sclera a few millimetres from the ciliary body. They lie not in the horizontal meridian but below it, corresponding in position with the lower edge of the tapetum. They will be seen again in the picture of the ciliary body.

These successive sections show how greatly the thickness of the sclera diminishes towards the front of the eye.

FIG. 7 shows one of the upper *vortex veins* on its passage through the sclera. Care was taken to cut it at right angles with its course and with the surface of the sclera so as to avoid modification of its shape by oblique sectioning. The yellow cores that filled the lumen have dropped out. The upper section shows the vein entering the inner surface of the sclera near to the ora serrata; the lower shows it about to reach the outer surface near to the equator.

The anterior ciliary vessels are very much smaller than those which enter the posterior hemisphere. The two main arteries seen in Fig. 1 have, as a rule (under an injection-pressure of 100 mm. Hg.), an aggregate cross-section of approximately 2 sq. mm. The anterior ciliary arteries and veins together, so far as I could discover them in a circum-corneal zone of sclera 15 mm. wide

(there were about 32 in all) gave an aggregate of less than 0.05 sq. mm. Evidently a very large proportion of the blood that reaches the interior of the eye enters by the posterior vessels.

The larger vessels of the choroid are brought to view by separating the membrane from the sclera and brushing away its outer loose pigmented coat. As in the human eye, the arrangement of the arteries differs widely from that of the veins. The area drained by the upper pair of vortex veins is marked off from that drained by the lower by a horizontal seam or raphé extending right across the membrane about 5 mm. above the centre of the nerve. Innumerable veins arise here and, joined by others as they go, pass upwards and downwards in long sweeping curves to unite ultimately in the vortex veins. The arteries are less conspicuous. On reaching the choroid through the sclera they are already much smaller and much more numerous than are the veins that leave it to pass out through the sclera. They enter chiefly in the neighbourhood of the nerve and horizontal raphé. Their branches lie at first outside the veins, often crossing them at large angles and showing remarkable tortuosity; later they take the same direction as the veins and run between them towards the periphery. In doing so they decrease in diameter while the veins increase. The arrangement has an exceptional result: arterial and venous streams running side by side move in the same direction.

FIGS. 8 to 12 show these vessels in various parts of the choroid under the same enlargement as used for the previous series.

FIG. 8. The nerve-aperture and the horizontal raphé.

FIG. 8a. The plexus surrounding the aperture for the optic nerve. Many arterial twigs are seen overlying the veins and directed towards the nerve.

FIG. 9. An artery cut through where it leaves the sclera, with branches passing in various directions. In two entire choroids with well injected vessels I found no larger artery than this; nearly all were smaller.

FIG. 10. A vortex vein together with most of its choroidal tributaries. The latter, anastomosing freely as they pass forward, coalesce near to the anterior limit of the choroid to form great transverse veins which, with slight interruptions, make a circle round the eye (the circle of Hovius) at the posterior edge of the ciliary muscle and beneath the ora serrata. These transverse veins receive also numerous tributaries from the ciliary body and iris, hidden here by the ciliary muscle. They unite to form the great vortex trunks, giving pictures that remind one of a "weeping" ash tree. The trunks, usually 4 in number but occasionally 5 or even 6, lie obliquely between the vertical and horizontal meridians of the eye, and rather nearer to the former than to the latter, an upper and a lower pair, as in the human eye.

FIG. 11 shows the meeting place, on the vertical meridian, of the areas served by the upper (or lower) pair.

FIG. 12 shows the meeting place, on the horizontal meridian, of an upper with a lower area. Here the twin long posterior ciliary arteries are visible between their emergence from the inner surface of the sclera (see Fig. 6) and their entrance into the ciliary muscle.

The capillaries of the choroid and their stems.—The capillary network lining the choroid differs in character in different places. All the figures in this group have an enlargement of 50 diameters, and each of the squares represents 1 sq. mm. of surface.

FIG. 13 is from the tapetal area at a point near to the posterior pole of the eye. Here the network shows numerous roundish figures, the "stars of Winslow," in which the freely anastomosing tubes tend on the whole towards a central stem, as the spokes of a wheel to the axis. Around the axis the meshes are at their smallest. many of them being minute rounded apertures covering less space than the surrounding tubes; nearer to and at the circumference of the wheel they are elongated, but much less so than in the non-tapetal area.

The wheels join each other without clear lines of demarcation. They have an average diameter of about 0.2 mm., but they vary in size and in some places are hardly definable. Each wheel is joined below not only by a stem at its centre but by others at or near to its periphery. The axial stems are the larger, the peripheral the more numerous. It will be shown immediately that the former are probably venous, the latter arterial.

FIGS. 14, 15 and 16 are from the non-tapetal region below the horizontal dividing line. Here the meshes elongate more and more as the periphery is approached. The wheels are gradually replaced by larger tree-like or feather-like forms with larger and fewer stems. The membrane becomes thinner. Near to the periphery the large veins lie close beneath the capillary layer and are seen through it almost as clearly as from the outer side. FIG. 14 was taken from a spot a few millimetres below the edge of the tapetum and near to the vertical meridian. FIG. 15 from the same preparation, but nearer to the equator. FIG. 16 from the same eye as FIG. 13, but near to the periphery. In the first and last the injection was fuller than in the others.

The difference between the tapetal and non-tapetal areas as regards the capillary network is significant: one can hardly doubt that the smaller meshes correspond with greater retinal activity. Is there any difference of this kind between one part of the tapetal area and another?

FIG. C represents an attempt to answer the question. An exceptionally well injected choroid was skilfully removed in one

piece by Mr. Lowe. It was flattened out by radial incisions and mounted as here shown. The capillary surface, under enlargement of 65 diameters, was examined in many places. At the sites figured 0, 1, 2, etc., the axes of the wheels, so far as distinguishable, were plotted on paper by means of the Leitz prism. A piece of glass, 65 mm. square, laid on each drawing in turn, showed the number of wheels in 1 sq. mm. at each site. Here are the numbers:

Site ...	0	1	2	3	4	5	6	7	8	9	10	12
Wheels	21	23	22	24	23	21	21	17	23	18	11	14

The counts could not be made with great precision for reasons already given, but I think they are accurate enough to show that the distribution of the wheels is fairly uniform over a large part of the tapetal area. Near to its upper curved margin (7, 9, 10, 12)

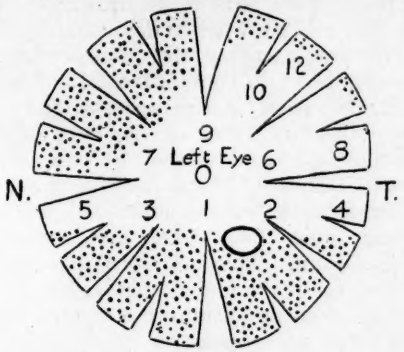

FIG. C. Natural size.

they certainly lie less closely. Near to the lower straight margin (1, 2, 3, 4, 5) they seem nearly uniform throughout; at the two ends of this strip (4, 5) the capillaries are less well filled than in the middle (1, 2, 3), but the network does not appear to be less close.

So far as this observation goes it shows that the nourishment of the retina by the choroidal capillaries is fairly uniform over a large part of the tapetal area, and supports the supposition (of Lindsay Johnson and others) that animals devoid of a macula lutea have an area of relatively good vision much larger than that afforded by the macula in man. But it does not preclude the idea that certain parts of the tapetal region are somewhat more sensitive than others. The *retinal* capillaries (see later) suggest that a horizontal strip immediately above the lower margin of the tapetum is particularly active.

The minute stems that connect the capillary plexus with the underlying vessels were examined in various ways, the special aim being to ascertain their number in a given area and to distinguish the arterial from the venous.

FIGS. 17 and 18 are from thin sections of the choroid perpendicular to its surface in the tapetal region near to the posterior pole. The one cuts the larger vessels transversely; the other runs parallel with them. Between the larger vessels and the capillary layer lies the transparent tapetal tissue and passing upward through it are seen many stems. The length of the part seen in each case is 1 mm.

FIG. 19 is a similar section from the same piece of membrane, but from the non-tapetal region near to the periphery. It cuts some of the larger veins transversely not far from the vein of Hovius, and the small arteries between them (compare Fig. 12).

FIG. D is from a prism-drawing of a thin section taken from the tapetal surface near to the posterior pole; it represents 1 sq. mm. Photography proved inapplicable here because of reflex from the tapetum. The plane of the section just misses the capillaries at the upper part of the picture; elsewhere it lies close beneath them cutting their stems. The lower half of the picture shows 60 stems; a whole square should, therefore, contain about 120. Many such counts were made in different parts of the tapetal area; some in sections like the present, others in pieces of the choroid from which the capillary membrane had been brushed or scraped away so as to expose the stems. Taking 18 of the satisfactory counts, I find an average of 118 stems to the square millimetre, the maximum being 132, the minimum being 104. Their distribution even in small areas is not quite uniform. They often tend to run in lines following, no doubt, the direction of the underlying vessels.

With the object of distinguishing the arterial from the venous, Mr. Lowe kindly, at my request, varied the injections in several ways: (a) Vermilion was substituted for the lead chromate, in the hope that the larger granules might be arrested in the arterial stems, leaving capillaries and venules empty. This partially succeeded. (b) Finely ground vermilion was injected through the artery, lead chromate simultaneously through a vortex vein. Both reached the capillary plexus, but in a capricious and inconclusive fashion. (c) Vermilion was injected through a vortex vein under low pressure. This gave decisive results:—

Fig. E is a prism drawing like the last. The eye was injected with vermilion through a vortex vein (the upper nasal) under a maximum pressure of 40 mm. Hg. The picture shows 1 sq. mm. of the tapetal surface (not a section) near to the posterior pole and in the area served by the injected vein. It shows 28 well injected stems of relatively large diameter, through which the vermilion has passed sparingly into the capillaries in dotted radiating lines—evidently the spokes of the wheels. These stems must be venous and are certainly the axes of the wheels. Two eyes were injected in this way and many counts were made in different parts of the tapetal area. In 9 of the most satisfactory the average number of

stems in 1 sq. mm. was 29, the maximum 33, the minimum 26. This somewhat exceeds the numbers previously found by counting the wheels themselves, but the wheels are less easily defined than their isolated stems. It is, I think, the truer estimate.

In round numbers, then, a square millimetre of the capillary network in the tapetal area is usually served by about 120 stems, of which about 30 are venous, i.e. by about 90 arterial and about 30 venous stems; a ratio of 3 arterioles to 1 venule. In each wheel the venule is at the centre, the arterioles are at or near to the periphery, and the current is centripetal. The arterioles join the plexus in such a way as to feed adjacent wheels, hence while their number in general is to that of the wheels about as 3 to 1, their number around each wheel is many more than 3.

In eyes injected through an artery, the choroidal capillaries are often found to be filled in numerous small patches not corres-

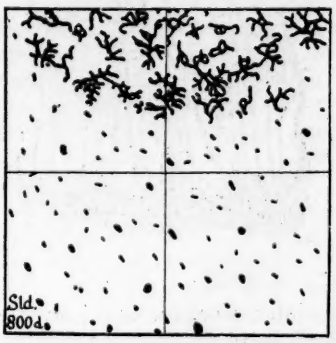

FIG. D. × 50.

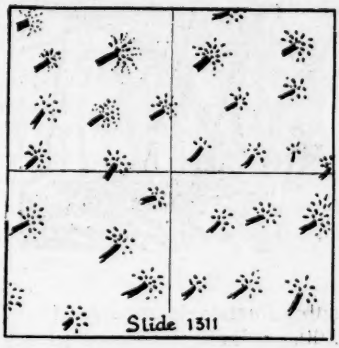

FIG. E. × 50.

ponding with the wheels, while the central parts of the wheels are comparatively free. The mass has reached the capillaries through the arterioles and has passed along them a little in various directions, but has failed to reach the venules. The appearance produced by incomplete injection through a vein is different (compare Figs. D. and E.). Note, however, that injection through an artery may fail to reach the choroidal capillaries through the arterioles, and yet do so indirectly by passing through the ciliary capillaries into the choroidal veins, and thence backwards into the venous stems. Leber made note of this. If it be overlooked the findings may be inexplicable.

The vessels of the ciliary body are somewhat more difficult to follow.

FIGS. F. and G. are from the blood-injected eye of an albino rabbit (*see* p. 338). Thanks to the absence of pigment and the thinness of the membrane in this animal, the general arrangement of the larger vessels in their several layers could be seen at one

view. Fig. F. is from the horizontal meridian and shows the entrance and bifurcation of the long posterior ciliary artery—single in the rabbit. Fig. G. is from an oblique meridian near to a vortex vein. The external surface is towards the observer. At successive depths are seen the major circle (in the iris) sending branches to the processes and iris, the veins that carry blood from these structures to the vein of Hovius, and indistinctly the processes themselves attached anteriorly to the iris. The arrangement in the ox has the same general character.

FIG. 20 shows the whole ciliary circle everted; it is considerably foreshortened in the vertical meridian. The full-length processes number about 96, and between their diverging tails are many

FIG. F. × 10.

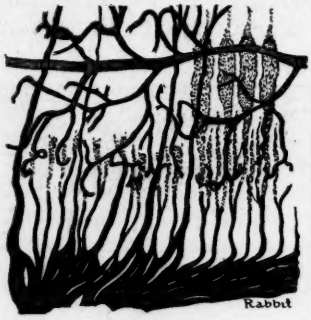

FIG. G. × 10.

subordinate ridges—from 1 to 5 in an interspace, and in all perhaps 300. Where the major processes thicken out these minor ridges subside or join them.

The processes consist of a vascular membrane coated with epithelium and highly convoluted. The visible size of a process gives no idea of the extent of secreting surface hidden in its interior. By way of rough illustration, a sheet of paper 10 inches square may be easily crushed into the form of a ball 2 inches in diameter. A solid ball of that size has a surface of less than 7 square inches, while the crushed paper has a total surface of 200 and no part of it is cut off from the air outside. The ciliary membrane, unlike the paper, is folded in a definite way. It has an attached base and a greatly extended free border like the mesentery, and cannot be laid out flat. Mr. Lowe compares it aptly with a leaf of "curly cabbage." Besides forming the processes it lines the spaces between them and connects them by transverse folds.

FIGS. 21 to 24 show the membrane injected and denuded of its epithelium. Fig. 21 is from the lowest part of the circle, where the large vessels of the adjacent choroid are not hidden by tapetum; the

0 of the scale tells approximately the position of the ora serrata. Fig. 22 is from the temporal side and includes a little of the tapetal area. Figs. 23 and 24 are from the same preparation as Fig. 21; the picture is cut off above at 6 mm. on the scale.

There is almost no *pars plana*. Within 1 mm. of the ora serrata the membrane begins to rise in vertical planes, reminding one, by the arrangement of the vessels, of espalier fruit trees. These as they pass forward curve and fold, laterally and otherwise, with increasing intricacy, and widen out until the bodies of the processes are formed and nearly touch each other. Here there are many transverse connecting folds. Near the tips of the processes the folds take a more longitudinal direction. Seen under the microscope, and especially in relief under the binocular, these preparations are of great beauty. Photographs, however well taken and reproduced, fail to do them justice.

FIGS. 25 to 30 are from longitudinal sections through the ciliary body. The small-scale picture includes the vein of Hovius on the left and part of the iris on the right; the others show isolated parts under a uniform enlargement of 25 diameters. In FIG. 26 the section splits a process so as to expose some of the vessels that pass from the base into the free portion. It does not show the full depth of the process anteriorly. FIG. 27 shows the full depth. Near to the tip one sees a small part of the capillary network which happens to lie in the plane of the section. FIG. 28 shows a longitudinal fold from the tip of a process, flattened by the cover-glass so that the vessels are brought nearly to one plane.

In FIGS. 29 and 30 the "major circle of the iris" and some of its branches are seen cut transversely. The artery is larger in the former figure because it is seen near to the beginning of its circular course; in the latter it is nearer to its meeting place with the artery from the opposite side, and has given off many branches. FIG. 29 shows the vascular webs cut chiefly edgeways; FIG. 30 catches them more nearly on the flat. In these two pictures the processes look, of course, in opposite directions, as in the two next above them.

In FIG. 30 one sees one of the large veins that carry blood from the iris and ciliary processes to the vein of Hovius, and so to the vortex veins. The direction of these veins is at right angles with that of the artery; where they cross, the artery lies outside the veins, as in the case of the choroidal vessels.

FIGS. 31 to 37 show the ciliary body in transverse section at various points between the tips of the processes and the vein of Hovius; they are all from one series; their position in the circle corresponds with that of a vortex vein. The sections lay as follows:—FIG. 31: Near to the tips, which stand away from the iris and are more or less split into vertical folds. FIG. 32: Just before

the processes become attached to the iris; here the processes show large arteries and veins (compare FIG. 26) but the iris does not. FIG. 33: Through the region of the major circle. The tortuous artery is cut obliquely in two places; the processes are sessile and no longer contain large vessels; these latter are in the iris. FIG. 34: Through the necks of the processes. Beneath each process a vein passes backward through the ciliary muscle. Between this point and the vein of Hovius these veins become fewer and larger by coalescing, and smaller veins from the minor webs appear. FIG. 35: Through the tails of the processes, showing the major and minor webs, and the ciliary muscle. FIG. 36: Near to the vein of Hovius and the ora serrata. Here are large veins from the processes and iris, smaller vessels to and from the minor ridges, and a multitude belonging to the ciliary muscle. FIG. 37: Through large ciliary veins at their junction with the vein of Hovius, near to a vortex vein (*see* FIG. 43). There are no ridges. (In this section and in some others of the series, the membrane is abnormally curved, perhaps through swelling of the gelatin films while they lay in water. The processes stand on the inner surface; the outer surface, if discoverably curved, should appear slightly convex).

FIGS. 38 and 39, like the last, show transverse sections, but from the horizontal meridian where the long twin arteries enter, instead of from the meridian of a vortex vein. In FIG. 38 the arteries have entered the ciliary muscle but have not yet separated to take their circular course. In FIG. 39 they are passing beneath the vein of Hovius (small at this part of the circle) to reach the muscle. There are ridges even over the vein: at this part of the ciliary circle there is no *pars plana*.

FIGS. 40 and 41 show the processes sectioned in planes roughly parallel with the iris. The heads, divided longitudinally, are directed upwards; the tails, showing many lateral folds, downwards. The sections do not reach quite to either end. The second lies deeper than the first and cuts the larger vessels and the transverse webs. It will be noticed that there are more processes in a given space here, than in the previous series: they lie closer at some parts of the circle than at others. The forms here seen in the tails of the processes suggest a longitudinal rib or web throwing off lateral branches, but Mr. Lowe's comparison with the "curly cabbage,"—which is merely a membrane more and more extended and curved towards its free edge—will probably hold good. By embedding such a leaf in plaster of paris and slicing the block, I obtained forms much resembling those in question.

In man the ciliary membrane is probably less highly convoluted than in the ox; in the rabbit it certainly is so, and this, one would expect. The diameter of the ox's eye is at least twice that of the rabbit's eye; its superficies is therefore 4 times greater. If the

processes in both were built to one pattern the secreting surfaces would be roughly as 4 to 1. But this would not meet the requirements. The volume of the intraocular fluid in the two cases varies as the cubes of the diameters, viz. as 8 to 1, and if the function of the processes is the same in both, the secreting surfaces must bear the same proportion. Hence the greater complexity in the ox.

FIG. 42 is from a deeper section in the same region; it passes beneath the processes and opens the tortuous artery that feeds them, the major circle.

FIG. 43, shows a section parallel with the last but in the thinner part of the ciliary body near to the ora serrata. Here one sees several of the large veins from the processes and iris joining the vein of Hovius. The passage of the blood from the latter into the vortex veins and through the sclera has been seen already.

The vessels of the iris, apart from those which pass from the base of the iris into the ciliary body, and the other way about, are comparatively small. They have been seen already in transverse section in FIGS. 31, 32, and others.

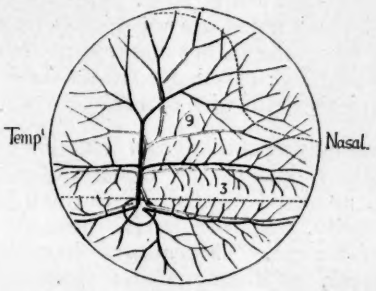

FIG. H.

FIG. 44 is from the posterior surface of the iris freed so far as practicable from its pigment epithelium. Capillaries are seen in the pillars and in the sphincter.

The vessels of the retina can only be glanced at here. Their entrance has been seen already (FIG. 4A). Their distribution differs from that in the human eye. The chief artery and vein, close together, superimposed, or even twisted, run straight upward from the papilla giving off branches more or less horizontally on each side. Trunks somewhat smaller run horizontally from the papilla to right and left below the lower margin of the tapetum, sending branches upwards and downwards.

Fig. H, sketched from injected preparations, and from uninjected specimens where blood remained in the larger veins, gives a rough idea of the general arrangement. A fine coloured drawing by Head of the fundus oculi of the Indian ox, is to be found in Lindsay Johnson's book, Plate 12.

FIG. 45 shows the ultimate branches of three retinal arterioles, the three corresponding venules, and their capillaries. Their situation was somewhat above the posterior pole (near to 9, FIGS. C and H). The injection was made with carmine-gelatin, the photograph was taken with transmitted light (for further description see BRITISH JOURNAL OF OPHTHALMOLOGY, 1918, p. 270).

FIG. 46 was taken from an exceptionally successful vermilion-gelatin injection, under surface illumination. It shows the vessels over the lower part of the tapetal area on the nasal side of the papilla (viz., site 3, FIGS. C and H). On the temporal side the appearances were closely similar, and in no other part was so dense a capillary plexus discoverable. This remarkable capillary tract—injected, found, and photographed by Mr. Lowe—has a special interest. It doubtless indicates an area of high activity, and corroborates what Lindsay Johnson says of the Indian ox: "Just above the disc, and extending in a horizontal manner on either side, is a rose-coloured band, nearly free from large vessels. It is probably the seat of acute vision."

FIGS. 45 and 46, be it noted, are not suitable for close comparison, for not only the enlargements, but the injection-methods also, were different in the two cases: carmine-gelatin without corneal puncture in the one, vermilion-gelatin with corneal puncture in the other.

From these various preparations and from many others, numerous measurements and counts of the blood-vessels have been made, for the purpose, as already stated, of learning something of the volume, the velocity, and the lateral pressure of the blood in different parts of the eye. That purpose has not been developed in the present paper, but it is not abandoned.

In conclusion, I desire to express my gratitude to my helpers: to Mr. Lowe whose collaboration is evident on every page; to Prof. Carlier for the opportunity of working in his laboratory; to Mr. Arthur Potts (R. Bailey) who, as a scientific optician, has given me kind and prompt aid in the matter of apparatus on very many occasions; to my one-time assistant, Miss F. Warth, especially for her good work with the drawing-prism; and not least to my wife for indispensable help in the cutting and mounting of sections and in countless other ways. I am indebted to the University for a grant towards the cost of illustrating this and the preceding articles, from the Aubrey Bowen Fund for the Promotion of Ophthalmology.

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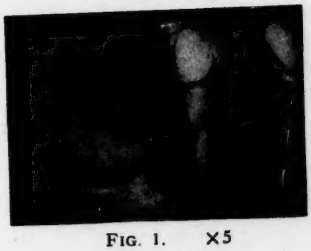

Fig. 1. ×5

Fig. 2. ×5

Fig. 3. ×5

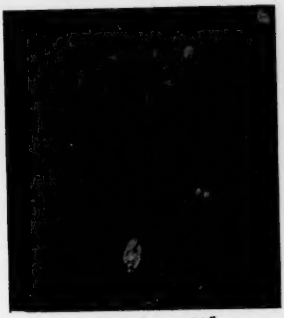

Fig 4. ×5

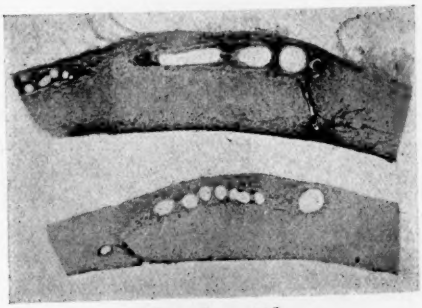

Fig. 5. ×5

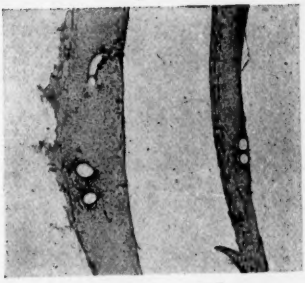

Fig. 6. ×5

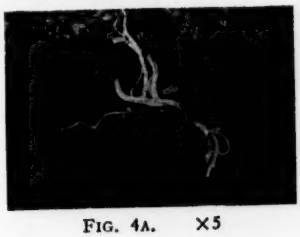

Fig. 4a. ×5

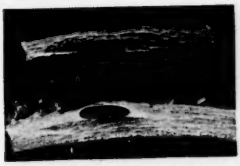

Fig. 7. ×5

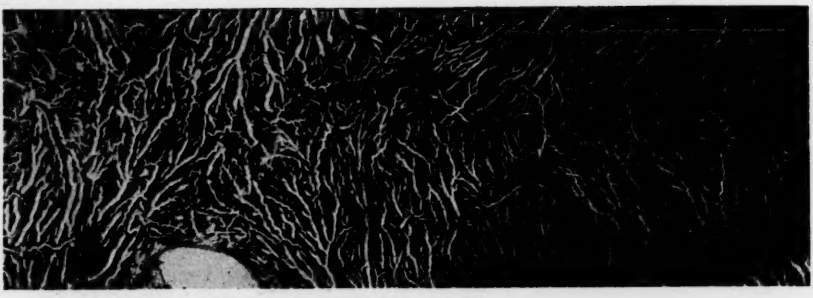

FIG 8. ×5.

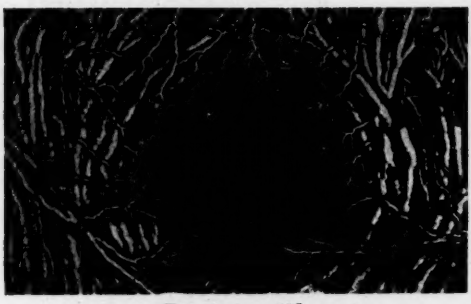

FIG 8a. ×5

FIG. 11. ×5

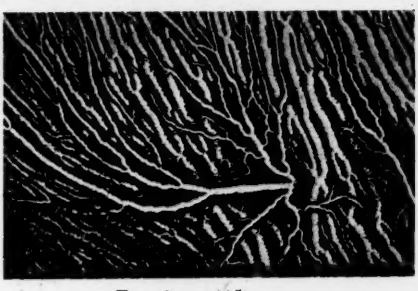

FIG. 9. ×5

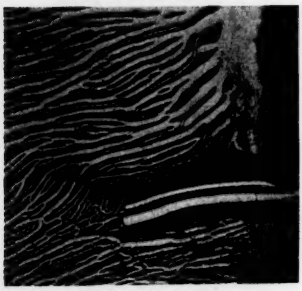

FIG. 12. ×5

FIG. 10. ×5

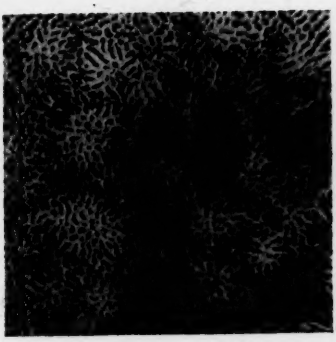

FIG. 13. ×50

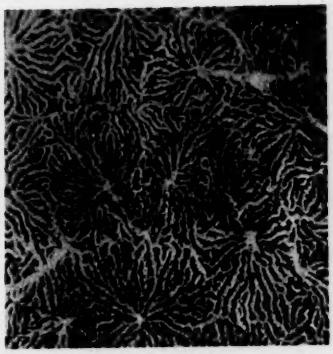

FIG. 14 ×50.

FIG. 15 ×50

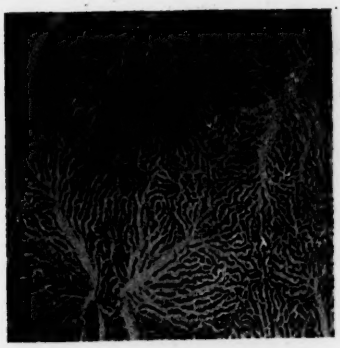

FIG. 16. ×50

FIG. 17. ×50

FIG. 18. ×50.

FIG. 19. ×50

FIG. 20. ×1.5

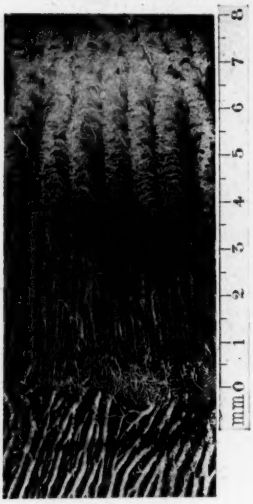

FIG. 21. ×7

FIG. 22. ×7

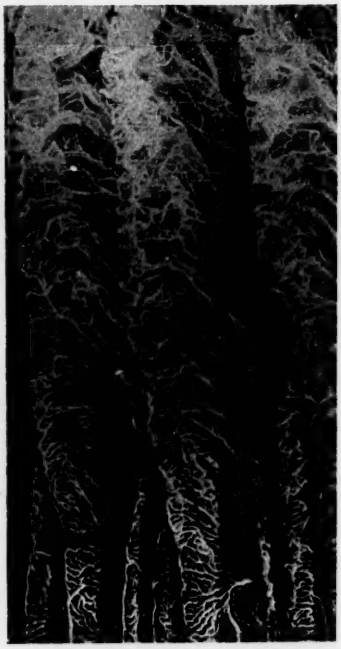

FIG. 23. ×25

FIG. 24. ×25

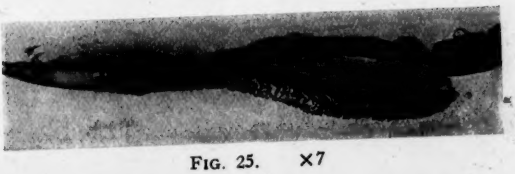

FIG. 25. ×7

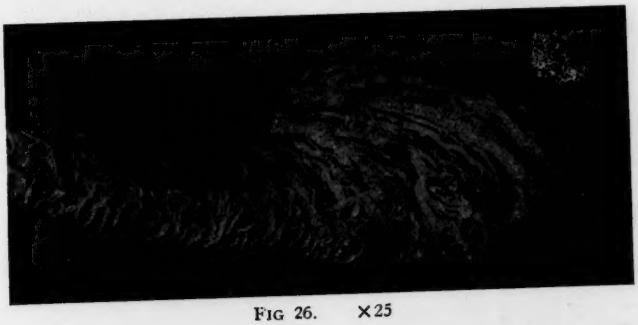

FIG 26. ×25

FIG. 27. ×25

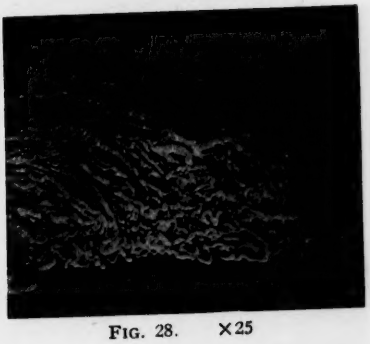

FIG. 28. ×25

FIG. 29. ×25

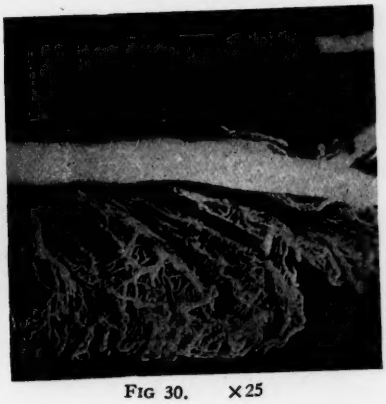

FIG 30. ×25

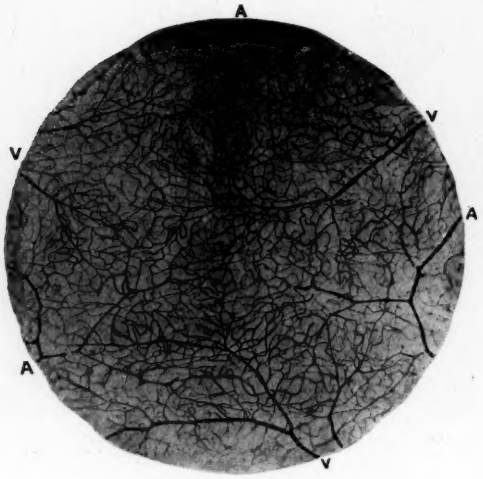

FIG. 145. ×30

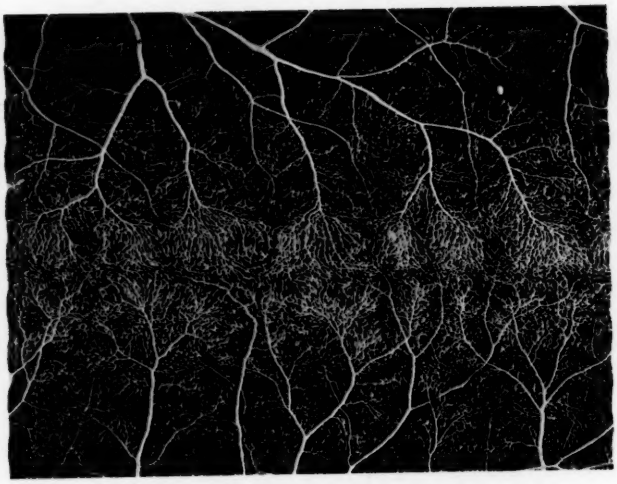

FIG. 46. ×15

THE OCULAR MENACE OF WOOD ALCOHOL POISONING*

BY

DR. S. LEWIS ZIEGLER

PHILADELPHIA

Continued from page 373

Whether the ganglion cells of the retina or the fibres of the optic nerve are first attacked has never been decided. Birch-Hirschfeld, Holden, and de Schweinitz endorse the former view. Most of the conclusions reached have depended upon animal experimentation, but post-mortem degeneration of these delicate structures is so rapid that a satisfactory study is difficult to make. As I have elsewhere stated it is most unfortunate that so much excellent human material has recently gone to waste without a single microscopical report being made. According to Fridenberg, both of these highly energized tissues are seriously injured by contact with the formic acid, which like its congener, the bee sting, creates strangulation by the sudden tissue swelling or oedema which follows exposure to such a corrosive poison. The corrosion does harm and so does the swelling. Whichever tissue is touched first will be injured first. As the serous infiltration subsides and strangulation is removed, the vision improves, but if the nerve fibres are corroded and later undergo shrinkage, vision is finally lost. The injury is modified, therefore, by the degree of concentration of the circulating poison which seems to have a selective affinity for these delicate tissues.

A critical study of the phenomena occurring in cases of wood alcohol poisoning and more especially the characteristic symptoms noted in Case VI, herein reported, have led me to the conclusion that the primary and fundamental lesion in all cases of methylic poisoning is a ***profound injury of the pituitary body.*** The acute toxic symptoms are typical of such a lesion, while the chronic symptoms are equally significant. A similar lesion of the pituitary may possibly be found in quinine and other toxaemias. The tentative diagnosis of encephalitis lethargica in my case is also suggestive, since the symptoms of that disease indicate a pituitary lesion. The changing but steadily contracting fields, the fugitive scotomata, the visual loss and recovery, the sclerosed or atrophic nerveheads, the fixed and dilated pupils, the temporary paresis of the extraocular muscles, the ptosis, the ataxic gait and the mental hebetude are all characteristic of pituitary involvement.

The fields of vision usually reveal a concentric contraction for both form and colour. Central scotomata are often present but not always permanent, as many recoveries have been recorded. Tyson

*Read at the Oxford Ophthalmological Congress, July 15, 1920.

FIG. 20. ×1.5

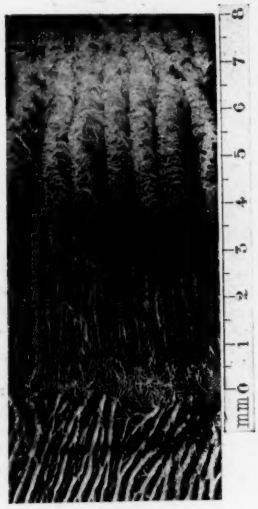

FIG. 21. ×7

FIG. 22. ×7

FIG. 23. ×25

FIG. 24. ×25

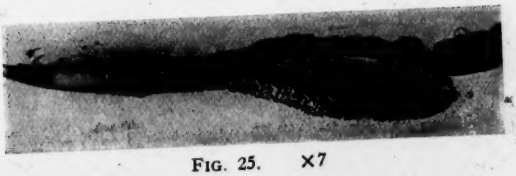

FIG. 25. ×7

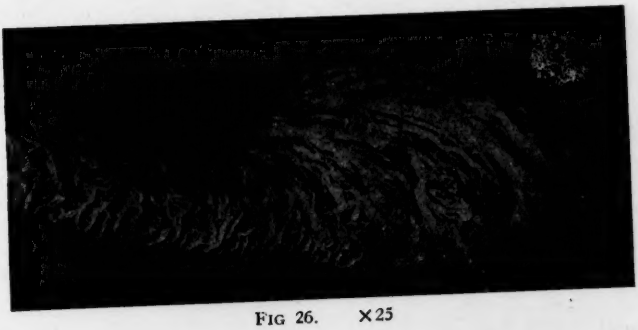

FIG 26. ×25

FIG. 27. ×25

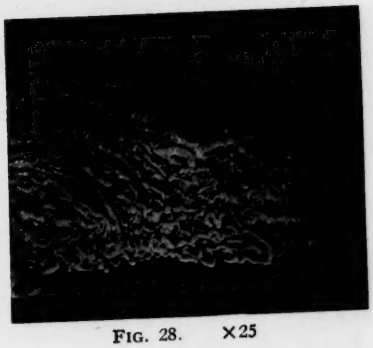

FIG. 28. ×25

FIG. 29. ×25

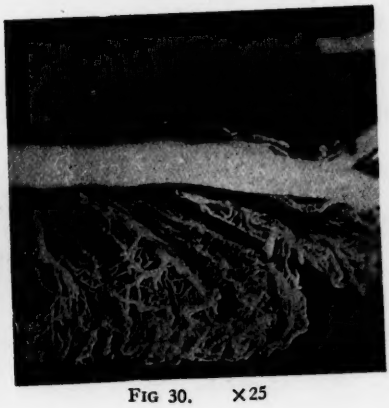

FIG 30. ×25

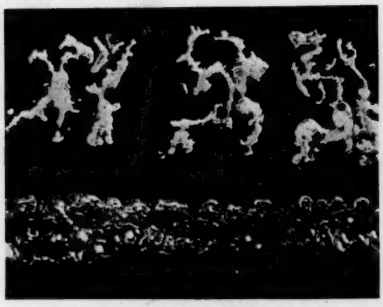

FIG. 31. ×15

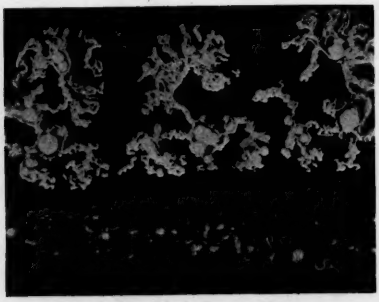

FIG. 32. ×15

FIG. 33. ×15

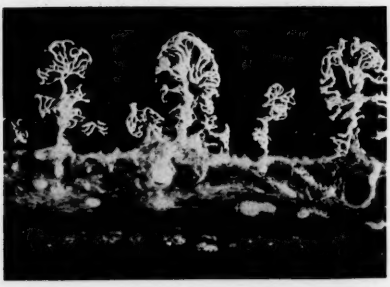

FIG. 34. ×15

FIG. 35. ×15

FIG 36. ×15

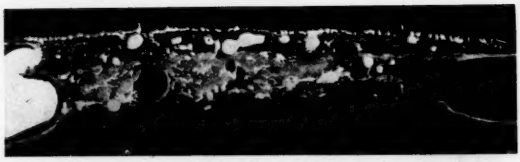

FIG. 37. ×15

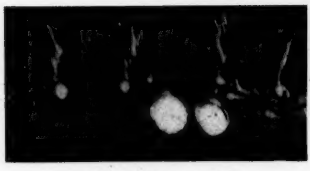

FIG. 38. ×15

FIG. 39. ×15

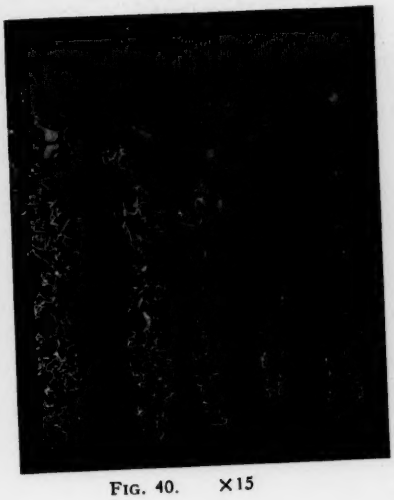

Fig. 40. ×15

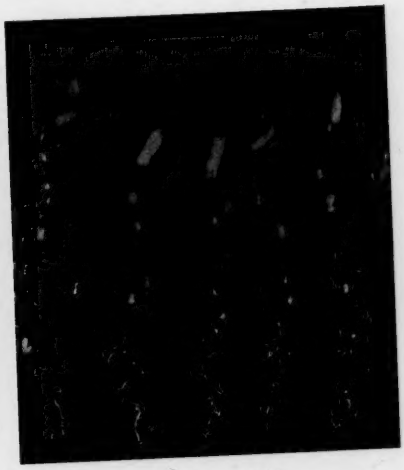

Fig. 41. ×15

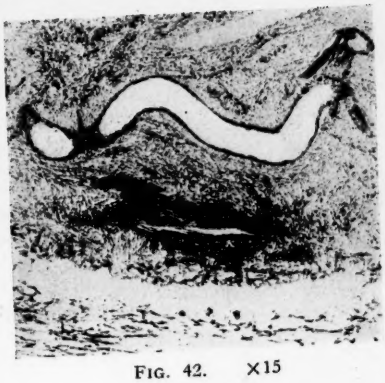

Fig. 42. ×15

Fig. 43. ×15

Fig. 44. ×15

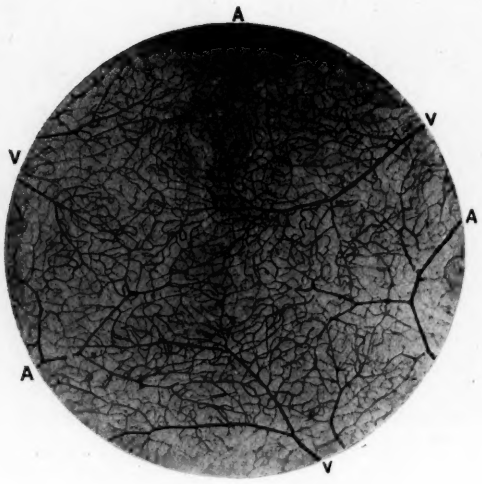

FIG. 145. ×30

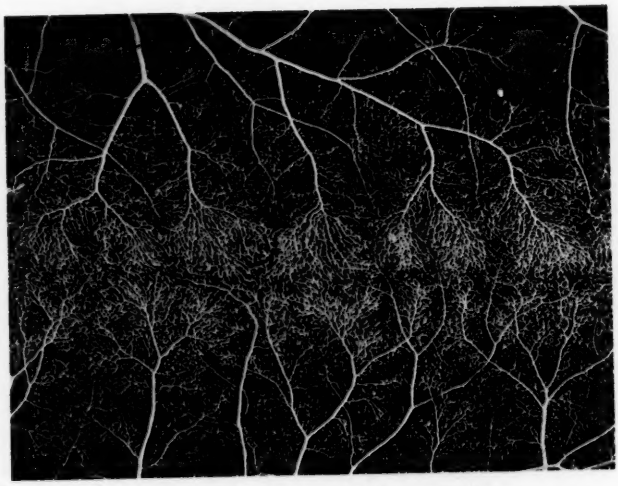

FIG. 46. ×15

THE OCULAR MENACE OF WOOD ALCOHOL POISONING*

BY

DR. S. LEWIS ZIEGLER

PHILADELPHIA

Continued from page 373

Whether the ganglion cells of the retina or the fibres of the optic nerve are first attacked has never been decided. Birch-Hirschfeld, Holden, and de Schweinitz endorse the former view. Most of the conclusions reached have depended upon animal experimentation, but post-mortem degeneration of these delicate structures is so rapid that a satisfactory study is difficult to make. As I have elsewhere stated it is most unfortunate that so much excellent human material has recently gone to waste without a single microscopical report being made. According to Fridenberg, both of these highly energized tissues are seriously injured by contact with the formic acid, which like its congener, the bee sting, creates strangulation by the sudden tissue swelling or oedema which follows exposure to such a corrosive poison. The corrosion does harm and so does the swelling. Whichever tissue is touched first will be injured first. As the serous infiltration subsides and strangulation is removed, the vision improves, but if the nerve fibres are corroded and later undergo shrinkage, vision is finally lost. The injury is modified, therefore, by the degree of concentration of the circulating poison which seems to have a selective affinity for these delicate tissues.

A critical study of the phenomena occurring in cases of wood alcohol poisoning and more especially the characteristic symptoms noted in Case VI, herein reported, have led me to the conclusion that the primary and fundamental lesion in all cases of methylic poisoning is a ***profound injury of the pituitary body.*** The acute toxic symptoms are typical of such a lesion, while the chronic symptoms are equally significant. A similar lesion of the pituitary may possibly be found in quinine and other toxaemias. The tentative diagnosis of encephalitis lethargica in my case is also suggestive, since the symptoms of that disease indicate a pituitary lesion. The changing but steadily contracting fields, the fugitive scotomata, the visual loss and recovery, the sclerosed or atrophic nerveheads, the fixed and dilated pupils, the temporary paresis of the extraocular muscles, the ptosis, the ataxic gait and the mental hebetude are all characteristic of pituitary involvement.

The fields of vision usually reveal a concentric contraction for both form and colour. Central scotomata are often present but not always permanent, as many recoveries have been recorded. Tyson

*Read at the Oxford Ophthalmological Congress, July 15, 1920.

noted in his chronic cases, multiple scotomata scattered over the fields. Occasionally, both the fields and the central vision are preserved in spite of the apparent sclerosis of the nervehead.

History of Cases

I will briefly report a few cases:

CASE I. Housewife, 49, seen by me 10 years ago and reported before the Pennsylvania State Medical Society in 1910. Indulged in a single alcoholic drink on Christmas eve, 1909. Jamaica ginger was suspected. This was followed by sudden and complete blindness the next day. Sclerotics were yellow. Had a spasmodic "stomach" cough for several days. Now blind in both eyes; pupils wide and fixed; feeble light reflex in O.D. Nerve heads sclerosed, dull white, but no shrinkage; vessels attenuated.

Thryoid extract given; negative galvanism advised. Acidosis not tested. Electrical treatment was begun January 19, 1910. One month later right disc became vascularized and left slightly hyperaemic. At the end of second month she regained P.L. and gradually continued to improve until on October 1, 1910, vision was O.D., 20/50 J-10, O.S. 20/100 J-14. The fields began with a very small central area and broadened out proportionately. This vision was maintained for several years, but recent reports are not so favourable. If her acidosis had been treated in the early stages and she had persisted with her galvanic treatment I believe this vision could have been maintained.

CASE II.—Male, 46, seen by me at about the same period; sudden blindness followed the drinking of a bottle of fortified cider bought at a country grocery store. When first examined the acute symptoms had subsided and vision had returned to about 2/200 in each eye. The nerve heads were pale, edges distinct, slight central cupping. Fields were concentrically contracted. A trial of galvanism was made but without improvement in vision.

CASE III.—Male, 40, previously referred to as resulting from inhalation, was under treatment for several months with failing vision, slight pallor of disc and contraction of fields without apparent cause. I finally directed him to keep a diary of his daily activities, hoping to discover something definite. One day I noticed the record of a visit to a china cement factory for one hour. He said he went there regularly every day but forgot to record it previously. On examination of the cement formula wood alcohol was found to be a constituent. By cessation of his visits to the factory and the application of negative galvanism he slowly recovered normal vision and fields which he still retains.

CASE IV.—Marine, seen in June, 1919, by Dr. Connole, of Wilkes-Barre, Pa. (to whom I am indebted for the notes), and by Dr. Daland in consultation. After a bay rum debauch "two sailors

died and one went blind." Thirty-six hours after ingestion vision was reduced to P.L. and wholly lost two days later. Typical papillitis, 1.5 D. increasing to 2 D. and gradually receding.

The patient was immediately placed on alkaline treatment:—1. Lime water in milk. 2. Enteroclysis of 5 per cent. dextrose containing sodium bicarb. ʒij to the pint. 3. Sodium bicarb. by the mouth, gr. x every three hours. 4. Strychnia Sulph. gr. 1/3 in 24 hours, later gr. 1/5.

P.L. regained in two weeks and vision improved to practically normal after two months, at which time the margins of disc were distinct, reddish on nasal side, vessels contracted, with central cup showing lamina. Colour perception normal. Concentric contraction of fields; left, 10°, right, 20°; blind spot slightly enlarged. Patient was seen in France one year later by Dr. Dunbar, and claimed vision was excellent. Present condition not known.

CASE V. Recently reported by Dr. Mongel before the College of Physicians, of Philadelphia. Male, 21, had three drinks in a saloon on Christmas Eve, 1919, and three the next day. Remembers that liquor had a rusty, foul, ether-like odour and taste. In 48 hours vision was reduced to P.L. Pupils slightly dilated, respond feebly to light. Conjunctivae deeply injected. Anterior scleral vessels distended. Media clear. Severe neuro-retinitis. Papillae swollen, hyperaemic, margins blurred, oedema extending into retinal tissue. Retinal vessels dark, engorged, and tortuous. Urine highly acid, Sp. Gr. 1012.

Treatment:—1. Gastric lavage; 2. Salines through enteroclysis; 3. Pilocarpin; 4. Hot packs; 5. Strych. sulph. gr. 1/30 t.i.d.; 6. Calcium chloride gr. x, q.i.d.

P.L. regained in two weeks, reached 20/50 in one month and became normal at the end of two months. Fields showed slight concentric contraction with central scotomata. The nerve, retina, and blood-vessels gradually cleared up. Calcium chloride and strychnia were continued for three months.

CASE VI.—Painter, aged 20, inhaled fumes while varnishing the engine room of a submarine for three days, in March, 1920. Dizzy the first day, hilarious the second, and nervous the third. Gastric pain and insomnia. Diplopia from paresis of external rectus. Ptosis and blindness soon followed. In three weeks began to improve. Diagnosis of encephalitis lethargica made by attending physician.

Now vision O.D. 20/70 J-14, O.S. 5/200 J-20. Pupils unequally dilated, O.S. wider; react to light and accommodation. O.D. nerve-head pale, central excavation, venous pulse, fine vascularization of disc. O.S. nerve pallor more marked, less vascularization. Excavation more extensive, venous pulse, veins overfull. Slight nystagmic movements. Exaggerated patellar reflexes. No static ataxia. Curious gait; lack of co-ordination suggests pituitary injury. Fields

limited for form and colour; no central scotomata. Marked mental hebetude.

Acidosis of early stages had changed to alkalosis, 113 per cent. This was gradually reduced by treatment to 65 per cent., which is practically a normal balance. Some backache, but urine is normal. Engorged nasal tissues interfere with breathing.

With negative galvanism and correction of refraction, central vision has improved to O.D. 20/15 pt. O.S. 20/20. Accommodation paralyzed. Add Sph. + 2.D = O.D. J-2, O.S. J-3. Fields have widened out. Less pallor of disc; vascularization has increased. Less mental hebetude and greater agility following the use of pituitrin.

The Biochemistry of Methyl Alcohol

The biochemistry of methyl alcohol as it passes through the system is somewhat complex. It is essentially a protoplasmic poison. The bulk of this poison is eliminated through the lungs, skin and kidneys, while the alimentary tract gets rid of a large portion. The remainder undergoes oxidation into formaldehyde and formic acid, both of which are corrosive poisons. The latter, however, will not oxidize further, but is slowly eliminated by the kidneys. Pohl, in 1893, showed that after ingestion of wood alcohol, the excretion of formic acid was increased in the urine. In wood alcohol workers this increase is so marked that Fehling's solution is promptly reduced. This chemical fact should always be borne in mind or sugar will be suspected and a false diagnosis of diabetes made by the inexperienced.

Acidosis seems to be a constant condition in the early stages. Tyson has demonstrated acidity of the aqueous humor in some of his cases. Judging from my experience in Case VI, alkalosis may appear in the later stages. These chemical reactions will be revealed by Van Slyke's test for carbon dioxide in the blood. If the attack of acidosis is acute, and of a severe type, it may manifest itself by the Kussmaul type of breathing.

Treatment

Acidosis should be overcome by the early administration of alkalies. Harrop reports good results obtained in a case of acute acidosis of great severity treated by him at Johns Hopkins Hospital, in which he made intravenous injections of from 400 to 500 cc. of a 5 per cent. solution of sodium bicarbonate on succeeding days. He governed his indications by Van Slyke's test. We should always bear in mind, however, that excessive alkalosis may cause grave irritation of the kidney, and that as soon as tests show that the plasma bicarbonate has returned to normal no more alkali should be given. We already know that the oedematous swelling

caused by a bee sting can be reduced by alkalies. It will, therefore, be a great advance in the treatment of methylic poisoning if we can relieve this acute acidosis by the early use of alkalies, and thus lessen the destruction of nervous tissue.

Connole's case shows the value of comparatively small doses of sodium bicarbonate, given by the mouth and by enteroclysis. The vision promptly improved, and was maintained for at least a year. Mongel secured equally good results with calcium chloride, but not sufficient time has elapsed for us to pass final judgment in his case. It will be interesting to watch whether these results are permanent.

According to Bongers, much of the wood alcohol in the system is returned to the stomach and can be removed by gastric lavage. He recovered in this way three times as much on the second and third days as on the first day. He also found that formic acid appeared in the washings as long as 27 hours after the ingestion.

Many observers have noted that those who vomit early and freely are not so seriously injured by the poison and recover with less impairment of vision. It will be necessary to decide, therefore, whether emesis through mustard or apomorphin is indicated, or whether daily lavage will prove of greater utility. The stomach pump should be used early if the patient is seen early and methylic poisoning is suspected; but most victims are so secretive in the beginning that this is seldom possible.

Diaphoresis through hot packs, vapour baths or pilocarpin has frequently been employed with great success. Hot drinks also encourage this effect. Apomorphin and pilocarpin are both excellent lymphagogues in small doses. Jalap and saline purgatives have accomplished much good, but an alkaline enteroclysis may prove more useful because the absorbed water helps to dilute the poison and wash it out of the system, while the added alkali will help to neutralize the toxicity.

Oxygen has been used in methylic toxaemia to relieve cyanosis and support the heart, and yet it is an undetermined question whether this oxidation would not increase the virulence of the poison by converting the formaldehyde into formic acid. Harneck in a study of this question concluded that "Methyl alcohol by slow oxidation is converted into formic acid, while in rapid oxidation carbon dioxide and water were formed." Rapid oxidation may, therefore, be a valuable suggestion in the chemistry of metabolism. In a former paper on wood alcohol I recommended the use of potassium permanganate in order to oxidize rapidly the abnormal chemical compounds in the stomach, just as is done in opium poisoning, but I would prefer to have this suggestion tested out by animal experimentation before putting it into practice among humans.

It has been suggested that since deafness often ensues and there is uncertainty of gait together with certain head movements, the

middle ear is involved. I would rather believe that the pituitary body had suffered injury, since many of these symptoms point to such an origin. Case VI is very suggestive of this. In that event the use of pituitrin should prove of service, as it did in this case. Thyroid extract, however, was more useful in Case I.

If marked nervous symptoms develop the use of hyoscin hydrobromate may be indicated, but it should be used with caution as it will interfere with elimination unless pilocarpin is used to overcome this tendency. While potassium iodide has been freely used to eliminate the toxins during the more chronic stages, I would prefer to use Donovan's solution for this purpose. The tonic effect of large doses of strychnin must always be considered, but I have not observed success from the use of this drug.

To revascularize the disc and restore the lost function of the nerve, no measure can equal the stimulating effects of negative galvanism. The case of partial blindness through inhalation that I have previously referred to (Case III) recovered practically normal fields and vision after prolonged treatment with negative galvanism. The patient with sudden sclerosis (Case I) who was totally blind for two months, recovered half vision and fields under the use of negative galvanism for one year. Case VI also regained normal central vision from galvanic stimulation although the accommodation is still paralyzed.

Negative galvanism should be administered with great care, using a high voltage and low amperage. Sixty volts should be passed through the main shunt controller, with the amperage reduced to one milliampere by a secondary carbon controller. The current is passed for ten minutes, and then reduced to one-half a milliampere and passed for a second period of ten minutes. These seances are continued on alternate days, as a rule. I believe that electricity is the most efficient therapeutic measure we have for the milder cases of toxic injury where there has not been complete destruction of the nerve fibres. If this has already occurred, as in my case of poisoning from bottled cider (Case II), galvanism will have no effect whatever.

In Conclusion

1. Wood alcohol is the most deadly poison used in daily commerce.
2. One teaspoonful has been known to cause blindness and one ounce to cause death.
3. The port of entry may be through the mouth, nose, or skin.
4. Wood alcohol should be identified by Robinson's test.
5. It is a protoplasmic poison possessing a selective affinity for the delicate nerve tissues of the eye.

6. Its biochemistry is modified by oxidation, first to formaldehyde and then to formic acid, both of which are corrosive poisons.

7. Formic acid is the end-product excreted by the kidneys.

8. If formic acid is present in the urine it will promptly reduce Fehling's solution, thus suggesting to the inexperienced a false diagnosis of diabetes.

9. Van Slyke's test will reveal acidosis in the early stages and alkalosis later.

10. Sudden blindness with vomiting and abdominal pain should always arouse suspicion of methylic poisoning; especially if diplopia or ptosis is associated.

11. Papillitis, sector-like atrophy, and sudden sclerosis of the nervehead are equally typical fundus lesions.

12. Symptoms of pituitary injury are most suggestive in pointing to this as the primary and fundamental lesion.

13. Contracted fields and central or paracentral scotomata are usually present.

14. Treatment should include early neutralization by alkalies, elimination by lavage, emetics, diaphoretics and rapid oxidation, together with stimulation of the optic nerve by negative galvanism applied directly to the eye. Thyroid extract and pituitrin may be indicated.

15. The manufacture and sale of wood alcohol should be prohibited or regulated by law.

16. If sales are permitted, safeguards and warnings should be required and the public instructed as to the great danger to vision and life.

17. A special revenue tax with registered "Poison Sales" would regulate and record its distribution and in cases of poisoning reveal the source.

18. This tax should equalize the cost of denatured alcohol and methyl alcohol, and thus remove the temptation to adulteration because of cheapness.

19. All wines, whiskies, toilet articles and patent medicines imported from foreign countries should be tested for wood alcohol before passing through the Customs inspection.

20. The name "Methanol" specifically designates this product and yet avoids the tempting suggestiveness of the word "alcohol."

SOME LATE GLAUCOMA RESULTS

BY

H. HERBERT, Lt.-Col. I.M.S. (Retd.)

BRIGHTON

IN the ordinary course of work, during the last two years in Nottingham, I came across eight examples of return of plus tension

some years after successful operations for primary glaucoma—two trephinings, three of my wedge-isolation operations, two small flap sclerotomies and one conjunctival-infolding operation. This experience suggested an enquiry into all the readily available later results of iris-free filtration operations performed five or more years before. Altogether slightly more than a hundred eyes have been examined, mostly operated upon by Mr. Laws or myself.

But a number of them have to be excluded from consideration in the main enquiry, i.e., with regard to the permanency of the relief obtained by these operations. Some of the operations were for secondary glaucoma following interstitial keratitis, iritis, or hypopyon ulcer of the cornea. Others have been rejected on account of incarceration or sub-conjunctival exposure of uveal tissue. Others because the history of the case or other evidence suggested that the reduction of tension might possibly have been a little incomplete from the beginning, or from a very early period. Two simple iridectomies have been included in the list because the scars showed undoubted filtration. On the other hand, one successful wedge-isolation operation with combined iridectomy was rejected because there was no definite conjunctival oedema to show filtration.

Thus, the number of primary glaucomas in which there was good reason to believe that the tension had been fully relieved for some years by iris-free* leaking scars is reduced to 69, in addition to the eight recurrent glaucomas which prompted the enquiry. In five of the 69 eyes plus tension had returned.

Thus, there are (8+5) 13 recurrent glaucomas and 64 still draining sufficiently, for examination. The mean period which had elapsed since operation in the recurrent group was 8 years, the maximum period being 13 years; the mean of the still successful list was nine years, the maximum 17 years. The earliest recurrence with more or less definite onset was more than 3 years after operation, the latest about 11 years. But in many the rise in tension was evidently very gradual, being spread over a number of years.

While not serving for even an approximate estimate of the percentage of late recurrence to the total successful operations, the figures are undoubtedly of value, expressing a real defect of iris-free drainage, and one that is frequently overlooked in present-day work. The figures as a whole, perhaps, compare favourably with what is known of the later results of classical iridectomy, but the defect must tend eventually to limit the application of the more moderate filtration methods to the less progressive glaucomas. Unfortunately the records of these cases are too imperfect to help at all in differentiating between types of glaucoma likely to be relieved

*The term "iris-free" is, of course, here purely a clinical one.

permanently by moderate drainage, and the more progressive forms, likely sooner or later to need additional drainage.

2. A sub-division of each group may be made according to the type of scar. In 5 of the 13 recurring cases the cicatrix was of the truly filtering type. That is, they were wholly visible, linear, of uniform greyish tint, under more or less oedematous conjunctiva. The cicatrices of the remaining 8 eyes were all judged to be in some degree fistulous. Either dark leaking points could be seen, or there was conjunctival opacity sufficient to make the scars invisible. Such a degree of opacity is found only with considerable conjunctival oedema, often with some tendency to central vesiculation. The tension of the eyes is usually a little sub-normal, and pressure on the eyes is generally very quickly effective in forcing fluid out from the anterior chamber, under the conjunctiva. Hence it probably always indicates one or more underlying fistulous openings.

Among the 64 glaucomas still satisfactorily relieved, there were 28 examples of true filtration, 32 fistulous scars, and 4 in which the distinction could not be made. Thus the proportion of diffused linear filtration in the non-recurrent list was certainly not lower than in the recurrent group, indicating that the full reduction of tension by the linear filtering cicatrix is at least as lasting as by small fistulae. (It may be taken that on the whole the fistulae in my list were smaller than the average of trephinings.) This seems to be an observation well worthy of notice, tending strongly to confirm the value of linear filtration in the milder glaucomas, since one dare not nowadays deliberately make iris-free sclero-corneal openings larger than appears necessary, having regard to late infective risks.

3. Careful examination of the present condition of the cicatrices and of the conjunctiva, both of the recurrent and non-recurrent groups, provides no clear evidence of any steadily progressive or recent changes indicative of late consolidation of the scars. On the contrary the evidence, such as it is, is almost entirely the other way, indicating that late insufficiency seems to be generally wholly due to increasing demands on the available drainage by advance in the fundamental glaucomatous changes.

Conjunctival conditions accepted as attributable to drainage of aqueous were definite in all the 13 late recurrences. Conjunctival oedema was noted as "good" in all the uniformly linear scars. In 2 of the partly fistulous cases pressure on the eye increased the oedema, while reducing the hardness of the eye; but generally this was not tested. In one case with opaque oedema ("cushion scar") there was a central partly vesicular area into which the conjunctival blood-vessels failed to penetrate. Yet the tension—evidently a quite recent exacerbation, with slight congestion of the eye—measured 70 McLean, and was very little reduced by finger pressure.

4. An extremely slow rise of tension, much slower than is met with ordinarily in untreated glaucoma, was a notable feature of some cases excluded from my list as being possibly somewhat imperfectly relieved throughout. Such cases are interesting in that they may account for many of the slow failures of vision after operation, which have been attributed to unchecked optic-nerve atrophy, proceeding in spite of supposed complete removal of abnormal tension. The tension in my cases remained for long so slightly raised that it was well within the limit accepted as normal for many eyes, as measured by the tonometer. But that it was actually raised a few degrees above the normal for these particular eyes was shown by a reduction obtained by a day or two's use of eserin, or by comparison with a more normal fellow eye, perhaps also by absence of conjunctival oedema,* and by the subsequent history of the case showing an increasing tension. One must admit that even the slightest persistently plus tension may conceivably destroy sight slowly. And how is one always to know exactly what is the normal measurement for any particular glaucomatous eye? One may go further with Mr. Treacher Collins, and suppose that the cupped disc may constitute a weak point like a staphyloma elsewhere, which may tend to bulge progressively under a tension which was previously normal to the eye, the tension required being now a sub-normal one.

In one patient small flap sclerotomy was performed on both eyes in 1910. In one eye the cicatrix became partly fistulous, but in the other eye no oedema developed at any time, and the greater part of the scar-line soon became difficult or impossible to locate, owing to firm healing. Drainage was obviously deficient, and the Schiötz tension, taken at intervals during the first three years after operation, was always higher than in the fellow eye. But the vision had not deteriorated, though it was without the improvement noted in the fellow eye. During the war, however, it slowly sank from fingers at 5 or 6 feet to perception of hand movements only. The Schiötz tension 1½ years after operation was 23, and even recently had only risen to 30, that of the successfully treated fellow eye remaining about 18 throughout.

In another excluded case the small flap operation was performed on both eyes in 1912. From about a month after operation the patient was not seen again till sent for recently. Though living very near he had allowed his sight to diminish very slowly and gradually from 5/6 and 5/15. Now it is hand-movements in one eye and *nil* in the other eye. The McLean tension, not recorded earlier, is still only 46 and 48. There are typical grey linear scars; oedema good in one eye, but doubtful in the slightly harder eye.

A patient, included in the list of late recurrences, came for recent dimness of vision six years after trephining of both eyes. Plus tension was well marked in one eye. In the other the Schiötz tension was only 23 or 24. But the use of eserin for a few days reduced it to 19, thus demonstrating plus tension, which was otherwise doubtful.

The following is apparently a case of steady diminution of vision in spite of fully lowered tension, but it was not a pure case of ordinary primary glaucoma. Two operations had been performed on the one eye for glaucoma. Part of the visual defect was due to central haze of the lens; the field of projection of light was good when the vision was at its worst. The tension while eserin was being used regularly measured 24 Schiötz, but to the finger there seemed no doubt at all regarding full reduction. The

*Recognisable conjunctival oedema may take several months to develop after one of the more moderate successful filtration operations; but its absence years after operation, while not precluding the possibility of some drainage taking place, is, in my experience, scarcely consistent with drainage sufficient for full relief of abnormal tension.

vision sank gradually in the course of seven months from 6/60 to fingers at 1 or 2 feet. Bearing in mind a case mentioned by Elliot, the patient's few teeth were then extracted, as they were in an unsatisfactory state. His vision began at once steadily to improve, and in 3½ months was 6/36, at which it still remains 5 months later. There were considerable pigmented extensions from the atrophic glaucomatous "halo" surrounding the fully cupped disc, one up and in, and a larger one down and out.

Cases such as the one just described are possibly deserving of fuller record than is here given. The old assumption of the very occasional occurrence of an atrophy of optic-nerve fibres, which was due solely to glaucomatous tension, and which yet progressed after complete removal of the abnormal tension, has always appeared very unsatisfying. Why should it occur so seldom? And it would naturally be seen particularly in the most advanced glaucomas, such as those mentioned in the next paragraph. But this is not so.

5. In my list of 64 primary glaucomas still successfully relieved, there were four cases of the very opposite result from the above-discussed progressive loss of vision, viz., the continued unimpaired preservation of a very small remnant of vision, existing at the time of operation in a limited portion of the field.

In two of the four cases the present vision is better than was recorded before operation, though the glaucoma was in both apparently non-congestive; in one case now fingers at three feet outwards seventeen years after iridectomy, in the other case fingers at four feet outwards seven years after a conjunctival infolding operation. Recent notes made regarding the two optic discs are "rather deep cup, but not of whole disc" and "disc white, shallow cupping."

In the remaining two cases the vision both before operation and now was only perception of moving bodies in the outer field; the operations were a small flap sclerotomy and a conjunctival infolding, both about seven years ago.

6. *Wedge-isolation results.* Wholly among the older cases were 19 of my wedge-isolation operations. But 3 of the 19 were among the excluded cases; 1 through absence of conjunctival oedema, and 2 through uveal impaction. In these two cases the wedge had been placed so far from the limbus that it had lain completely detached beneath the conjunctiva, and had hence become absorbed. (Similar disappearance of the wedge in other cases has not involved exposure or incarceration of iris.)

I wish particularly to refer to this group, since surgeons who have practised the method steadily for many years wonder why I gave it up for "less effective" or "reactionary and dangerous" procedures.* My reason was this: Though well pleased with my own results, and thoroughly convinced of the high possibilities of the method, I felt constrained to utilise my limited material in searching for a simpler operation, more suited, for example, to the

Proc. Roy. Soc. Med., Opth. Sec., 1921, p. 51.

average civil surgeon in India. Slight variations in the technique of this operation may produce large changes in the result, and though this is an advantage in the hands of the trained operator, suiting various grades and types of glaucoma, it is disconcerting to the beginner.

The method has a very obvious advantage over trephining, as will be readily understood from the growing recognition of the importance of spreading sub-conjunctival drainage over a wide area. And, as I have realised lately, it is particularly suited for use at the site of a previous wide iridectomy. The very narrow knife can be freely manipulated in the periphery of the anterior chamber without the slightest risk of injury to the lens. But, particularly, perhaps, where there may be some conjunctival adhesion from former operation, I think the covering conjunctival flap should be more freed above than in my old description.* Early elastic retraction of the flap may then be expected to cause slight bulging from accumulation of aqueous beneath it, thus producing a very desirable slight forward displacement of the sclero-corneal wedge.

Of the 16 (19 – 3) results included in my lists, 5 were in the recurrent and 11 in the non-recurrent list. The mean period since operation was 11 and 12 years respectively in the two groups. Three of the 5 recurrences were so recent and so intermittent as to have had little or no permanent effect on vision.

The feature which impressed one most in the whole series of these particular iris-free cicatrices was their very satisfactory appearance. There were no dangerous-looking scars. There were perfect examples of filtering lines still outlining the wedges. And in cases in which, a few months after operation, disappearance of ill-placed detached wedges had led to ugly and threatening sclero-corneal gaps, with hypotony, there were now the narrowest of slits under practically normal conjunctiva, only doubtfully distinguishable from true filtration. Possibly the change may have occurred almost entirely during the first two years after operation.

I have known of two late infections after this operation, but they were both mild and transient.

ANNOTATIONS

Motor Headlights

The important question of the best form of headlight for motor vehicles formed the subject of an interesting debate at a recent

*The Ophthalmoscope, Vol. V. (1907), p. 298.

meeting of the Illuminating Engineering Society. Major Garrard read a paper on the various optical measures that have been taken to reconcile the requirements of the driver who needs a powerful beam to distinguish objects ahead, and those of pedestrians or drivers of other vehicles who are apt to be dazzled by the brilliancy of the beam. The only practical solution at present available is one which limits the vertical height of the beam and this is the aim of the regulations at present in force in America, in which country, owing to the greater number of motor vehicles in use, the question is even more urgent than here. If the vertical height was all that mattered the problem would present no great complexity, but, as Major Garrard went on to point out, the satisfactory beam must be a composite one and must satisfy the three following conditions: "1. A fairly wide but relatively dim beam with a well-defined upper limit 3 or 4 feet from the ground so as to illuminate the hedges and ditches and the road in front of the car. This beam should preferably be of varying intensity so as to direct more light upon the more remote objects in, say, the middle distance. 2. A central but shallow penetrating beam of much greater intensity with a well-defined upper limit 3 or 4 feet from the ground for distance observation. This might extend about four degrees on each side of the axis, although it is difficult to suggest exact limits as the best results are probably obtained when the bright beam is shaded off fairly steeply into the wide beam. 3. A diffused or subdued beam having a very wide angle and corresponding to the light obtained direct from the filament of an ordinary electric headlamp without reflection." He did not attach much importance to 3, but considered that it might have a certain psychological effect, an effect that might also follow the use of a comparatively bright beam inclined upwards at such an angle that it is above the eyes of other road users. After discussing the various methods in use he concluded that a sufficiently definite line of demarcation between light and darkness is only likely to be obtained commercially by the use of at least one spherical, focussing or projecting lens or objective, and under this heading is included the Mangin mirror; which may be regarded as a combination of a reflector and a focusing lens. In the subsequent discussion some attention was drawn to the R.A.C. standard anti-dazzle disc for testing motor lamps, and specimens of lamps were shown. Possibly the time is not yet ripe for legislation on the subject, but as the number and speed of motor cars using the roads at night increases it would be of some value if an authoritative body such as the R.A.C. would take up the question of testing lamps and of issuing certificates with such lamps as proved satisfactory.

Cinema Studio Lighting.

As already announced the question of ill-effects from cinema studio lighting was referred to the Committee on the Causes and Prevention of Blindness, and it is interesting to note that on July 6 Captain Viscount Curzon asked the Minister of Health whether the Committee on The Causes and Prevention of Blindness had reported upon the question of injury to eyesight resulting from the extreme power of lights used in film production. Sir Alfred Mond told the House of Commons that he had received the Report of the Committee, and that the conclusion reached was that there was evidence only of transient injury to the eyes in a few cases and that such injuries were associated with the use of a particular arc-lamp without a proper screen. He had been assured by the Incorporated Association of Cinematograph Manufacturers that no member of the Association would permit any arc-lamps to be used in his studio for general illumination without glass screens and that in view of this assurance he did not consider further action necessary.

An International Congress of Ophthalmology.

All readers of the *British Journal of Ophthalmology* must by this time know that an International Congress of Ophthalmology will be held at Washington, D.C., on April 25, 26, 27 and 28, 1922. This Congress has been arranged under the auspices of the American Ophthalmological Society, the Section of Ophthalmology of the American Association, and the American Academy of Ophthalmology and Oto-Laryngology. By the courtesy of Dr. Edward Jackson, the Vice-Chairman of the General Committee, we have received for publication the first official announcements of the Committee on Scientific Business. They are as follows:—(1) A copy of each paper to be presented to the Congress, type-written in one of the official languages of the Congress (English, French or Spanish) must be submitted to Dr. Edward Jackson, of Denver, Colo., by January 1, 1922. (2) Every such paper must be accompanied by a brief abstract (100 to 300 words), also in one of the official languages. (3) Each accepted paper will be published, in full, in the language in which it was submitted, in a pre-session volume. (4) Each speaker in discussion may use such tongue as he prefers, but the substance of his remarks must be furnished for publication in one of the official languages of the Congress. (5) All papers presented to the Congress will be published in its Transactions, together with the discussions related to them. Such papers may also be published elsewhere, after they have been presented to the Congress, with the note that they have been so presented.

ABSTRACTS

I.—PERFORATING OCULAR INJURIES.

Thomsen, von H. (Copenhagen).—On the cases of perforating ocular injuries treated at the Kommunehospital Eye Department from 1905-1915. (Die in der Abteilung des Kommunehospitals behandelten Fälle von Vulnus perforans Oculi in der Zeit von 1905-1915.) *Klin. Monatsbl. f. Augenheilk.*, Feb.-Mar., 1917.

Thomsen has analysed all the cases of perforating ocular injuries treated at the Copenhagen Hospital for a period of ten years. These numbered 139, of which 37 were under 14 years of age. Of the children 80 per cent. were males and only 20 per cent. females. The proportions among the adults was similar. While the high proportion amongst the adults is naturally due to the nature of their occupations, it is not quite so obvious why there should be the same difference among the children. Thomsen attributes it partly to the nature of the games played, but also in greater degree to the small number of cases from which the statistics are drawn. Four-fifths of the adult cases were between fifteen and forty years of age. The right eye was injured in 74 cases and the left in 65 cases. The cause of the injury was very varied, but in only two cases did the injury result from broken spectacles. In 16 per cent. the eye was so severely injured as to necessitate immediate removal. In the treatment of some injuries use was made of conjunctival flaps.

Thomsen divides the cases into four groups:—1. Cases with foreign bodies; 36 cases. 2. Perforating corneal lesions; 51 cases. 3. Perforating corneo-scleral lesions; 40 cases. 4. Scleral lesions; 12 cases. In the first group 42 per cent. regained good vision, in 9 cases after extraction of the foreign body, in 9 cases after extraction of the foreign body and the opaque lens, and in 3 with retention of the foreign body. Forty-two per cent. had to have the eye enucleated, in the majority of which the foreign body could not be removed.

In group 2 cataract formed in 28 cases; 29·5 per cent. recovered useful vision, in one case after the removal of the cataract, while 27·5 per cent. required enucleation. In group 3 cataract occurred as a complication in only one case, and this case was lost through panophthalmitis. Of the remainder 32·5 per cent. recovered good vision and 50 per cent. were enucleated. In group 4, a much less common lesion, the lens was never injured. Twenty-five per cent. recovered good vision and 50 per cent. were lost.

The prognosis as regards enucleation in children and adults was

much the same. Thomsen's observations show the great importance of early treatment, as those eyes which were seen within six hours were lost in only 17 per cent. of cases, whereas those that came under observation more than a week after the injury were lost in 67 per cent. of cases, and the percentage of enucleations showed a steady increase between those two periods.

He next discusses the 32 cases of enucleation, in which he does not include the primary enucleations. Sixteen eyes were enucleated on account of panophthalmitis; 7 for iridocyclitis with or without raised tension; 2 for retained foreign body; 4 for beginning sympathetic ophthalmia (4 weeks, 2 months, 2·5 months and 9 months after the injury); 2 for phthisis bulbi; 1 for a large spontaneous protrusion 12 days after the injury (a 12 mm. corneo-scleral perforation). Thomsen found that intraocular haemorrhage was always of grave significance, but that the size of the wound did not seem so important. Although 4 cases were enucleated for fear of sympathetic, in only one case did this disease actually occur. This case was a boy of five years old seen two days after the injury, which involved the centre of the cornea reaching 2 mm. into the sclera. The prolapsed iris was cut off and the eye healed normally. Fourteen days later there was optic neuritis. Four weeks later the other eye was found to have deep ciliary injection with keratitis punctata with optic neuritis, and the vision which had previously been normal was then only 6/36. Inunction and atropin were used, but the former had to be interrupted on account of a rash. Thomsen had the opportunity of seeing this patient ten years later and found that the papilla in the injured eye was blurred but otherwise normal, vision 5/36; the iris in the other eye was tied down by numerous synechiae, but nothing abnormal in the fundus, the vision is given at less than 5/6. Thomsen concludes by contrasting his figures with those given by other observers.

E. E. H.

II.—THERAPEUTIC ANAPHYLAXIS

Aubineau, E. (Nantes).—Anaphylaxis induced by serum as a mode of treatment of intraocular haemorrhage of adolescents. (L'anaphylaxie sérique provoquée dans le traitement des hemorrhagies intraoculaires des adolescents.) *Bullétins et Mémoires de la Société française d'Ophtalmologie.* 1920.

The above is a short paper dealing with the profuse spontaneous haemorrhages occurring exclusively in young adults, characterized by frequent repetition, by inundation of the vitreous, and finally by retinitis proliferans. The pathology of the disease is obscure and

treatment unsatisfactory. **Aubineau** has had altogether 15 cases, of whom 12 were males, the ages ranging from 14 to 25 years.

Medical examination revealed nothing abnormal, no arterial tension, no kidney lesion and no syphilis. Sometimes there was a family history of tubercle; two cases showed signs of glandular insufficiency (thyroid and pituitary), two others had frequent nose bleeding. In eight cases a blood count was made, the red cells being deficient in one; in two an excess of polynuclear eosinophiles was noted and in four a deficiency of coagulability.

Five patients were treated with anti-diphtheritic serum in order to provoke anaphylaxis; a subcutaneous injection was first given (10 c.c.) followed 10 to 15 days later by successive sub-conjunctival injections of 1 c.c. In three cases nothing happened, in one local and general reaction followed but no amelioration of vision, and in the last a very gratifying result was obtained. Detailed notes of this case are given from which it appears that vision improved in the right eye from 1/100 to 3/10 and from practically nil to 1/10 in the left. Four months later there had been no relapse.

Aubineau observes that the improvement following each injection was too striking to be accidental and tends to support Dufour's view that anaphylaxis has an antihaemorrhagic action.

CHARLES KILLICK.

III.—VISUAL DISTURBANCES FROM INTRA-CRANIAL PRESSURE

Igersheimer, Professor (Göttingen).—Disturbances of conduction along the visual path through pressure from the sub-arachnoid space and ventricular system. (Leitungstörungen der Sehbahn durch Druck vom Subarachnoidealraum und Ventrikelsystem.) *Bericht der Ophthal. Gesellschaft*, Heidelberg, 1918.

A study of these disturbances has led **Igersheimer** to conclude that pressure of the fluid within these spaces upon the visual fibres, peripheral as well as central, is more frequent than has hitherto been supposed. Choked disc has been the symptom of increased intracranial pressure that has mainly occupied the attention of the ophthalmologist, but by use of improved methods in testing the field of vision he has been able to detect the presence of scotomata, through which one obtains an insight into pathological conditions, more particularly with regard to those produced by pressure from these spaces, such as it may be impossible to acquire from autopsies.

The author gives the histories of several cases to illustrate the effect of pressure from the sub-arachnoid space on the optic nerves,

and shows by the changes in the scotomata in the field charts the improvement or disappearance of the disturbance of function and other symptoms in the cases. This pressure, as these cases would indicate, may act either alone or in conjunction with other pathological processes (e.g., inflammation). How and where this pressure begins he will not say, but is of opinion that, since it is impossible to say at once in any affection of the optic nerve (apart from typical papilloedema) how far pressure from the sub-arachnoid space may be a contributory cause of the disturbance in function, lumbar puncture is always to be recommended both for diagnosis and treatment.

Cases with increased intracranial pressure are also cited; two of these (in which bitemporal hemianopic scotomata were found) show how the chiasma may be involved, and the resulting defects in conduction may occur, exactly as in the case of the optic nerves, with or without changes in the discs or vision or rise in the lumbar pressure; in one case, simulating disease of the hypophysis, with bitemporal hemianopic scotomata, conduction was affected through a combination of changes within the visual path itself and pressure from without.

In one case (? meningitis serosa) the homonymous hemianopia and other symptoms were successfully treated by repeated lumbar puncture.

The good effects of lumbar puncture in all these cases indicate with great probability, though not with absolute certainty, that abnormal pressure had been exerted on the visual path at some point. It is an important fact that such pressure may apparently arise even in spite of normal lumbar pressure, and that papilloedema may or may not be present. It requires, however, further study to determine why in many cases choked disc alone occurs, in others only a disturbance in conduction, while in others again both are combined.

THOS. SNOWBALL.

IV.—THE MIGRATION OF PIGMENT AND CERTAIN FORMS OF GLAUCOMA

Schieck, Professor (Halle a. S.)—The theory of the causation of certain forms of glaucoma by pigment migration and its influence on the choice of operation. (Die Anschauung von der Entstehung gewisser Glaukomformen durch Pigmentverschiebung und ihr Einfluss auf die Wahl der Operationsmethode.) *Bericht der Ophthal. Gesellschaft*, Heidelberg, 1918.

In a very large number of cases of glaucoma, as also in eyes in the pre-glaucomatous stage, examination with Gullstrand's lamp

reveals a peculiar migration of pigment in the iris. It is derived from the pigment epithelium on the posterior surface which, whether as a result of trophic changes or other causes, breaks down: the pigment particles thus set free wander in the form of fine dust into the iris stroma and finally become visible as a fine deposit on the anterior limiting layer of the iris. This dust is seen in the aqueous and on the posterior surface of the cornea, so that the natural inference in these cases is that the spaces in the iris angle are also blocked by this pigment.

Moreover, the anterior surface of the iris presents a peculiar dense appearance as if covered by a very fine membrane; this suggests a histological change which, Schieck submits, very likely extends to the iris angle, although it cannot be directly observed, and contributes to the blocking of the entrance to Schlemm's canal.

Clinical observation receives support from the pigmentary changes found on microscopical examination of glaucomatous eyes, and especially from a case published by Thomsen in which the only pathological condition present was a dense deposit of pigment in the spaces of Fontana and around the canal of Schlemm.

This theory, then, would indicate the line of treatment, and explain the manner in which operative procedure—iridectomy, anterior sclerotomy, or cyclodialysis—really acts.

As a type of other methods the author selects for discussion Elliot's operation as being the most useful for reducing the tension. His objection to it is the danger of late infection, and he prefers to do what would here be called the Fergus operation—trephining in the sclerotic with an anterior cyclodialysis—a procedure which, in removing the block at the angle, is in accord with the theory he here propounds, and is stated to be attended with uniformly successful results.

THOS. SNOWBALL.

V.—ON TREPHINING IN CONGENITAL HYDROPHTHALMOS

Fleischer, B. (Tübingen).—On trephining in congenital hydrophthalmos. (Ueber die Trepanation beim Hydrophthalmus congenitus.) *Bericht der Ophthal. Gesellschaft*, Heidelberg, 1918.

Between 1912 and 1917 Fleischer performed Elliot's trephine operation on seventeen eyes (two cases in young women and eleven in children under eighteen months) with results much more satisfactory than had previously been obtained from iridectomy.

In every case the operation passed off well; the trephining was especially easy owing to the stretching of the corneo-scleral margin.

Healing was uniformly good—the trephine opening, in the case of the children, being closed by smooth cicatricial tissue like the sclera. In only one of the adult patients did a cystoid cicatrix ensue.

As regards a reduction in tension, the results were good in all but two cases; in many the improvement was immediate, but in a few it was not apparent until after some months. One should therefore, he thinks, not too readily regard an operation as unsuccessful, and should undertake a second only when there is some urgent indication for it.

The vision ultimately attained depended on the duration of the disease; in seven cases that were operated on before the end of the first year the vision was approximately normal.

The results were better than those obtained by Haab with sclerotomy, with the advantage of not having to be repeated so often. Any danger for the future is obviated by the fact that the cicatrix is not fistulous.

Fleischer recommends this operation as superior to any other form of treatment. The one condition for success, as regards vision, is *early* operation—if possible, before the end of the first year.

He employed a 1·5 (or 1·75) mm. trephine, and made the trephine opening as far towards the cornea as possible.

THOS. SNOWBALL.

VI.—REMEDIES

(1) **Zimmermann, Charles (Milwaukee, Wisconsin).—Parenteral injections of milk in diseases of the eye.** *Amer. Jl. of Ophthal.*, Jan., 1921.

(1) **Zimmermann** gives a short survey of the therapeutics of milk injections, with a critical review of the results of various workers, and a report of two cases of his own.

He describes the technique and the general reaction of parenteral injections, but points out that the mode of action is not yet sufficiently known. High temperature appears to have a helpful influence upon the course of localized affections, in support of which view the author instances the improvement of trachoma in an epidemic of scarlet fever among 40 children. Whether due to the high temperature acting deleteriously upon the micro-organisms, or to leucocytosis, or to hyperaemia and transudation at the site of local inflammation is a matter of theory at present.

Zimmermann quotes favourable results from milk injections on the part of Berneaud, of Kiel, Maschler, Jickeli, etc., and doubtful or negative results on the part of many others.

His own cases (phlyctenular kerato-conjunctivitis with pronounced strumous diathesis) showed very gratifying results from single injections. He sterilized the milk for 10 minutes previous to injection into the gluteal region.

J. HAMILTON MCILROY.

(2) **Withers, Sandford, M.D. (St. Louis, Mo.)—Carcinoma of the eyelids treated with radium.** *Amer. Jl. of Ophthal.*, Jan., 1921, p. 8.

(2) **Withers,** in a short paper illustrated by telling photographs, gives the result of radium application in eight cases of carcinoma in the region of the eyelids.

The diagnosis of carcinoma in these cases was made by the consultant staff of the Barnard Free Skin and Cancer Hospital. Radium was usually applied in silver tubes enclosing glass capsules containing approximately 25 or 50 mgm. of the radium salt. The surrounding tissues were protected with lead 0.5 to 2 mm. thick; and a layer of gum rubber 0.5 to 1 mm. thick was interposed between the surface of the lesion and the radium applicators. For greater protection of the eyeball from prolonged exposure, a lead shield 0.5 to 1 mm. thick, fitting into the fornices like an artificial eye, was employed. This was dipped in melted paraffin to give it a non-conductive covering, and a few drops of liquid vaseline instilled under the lids made the introduction of the shield an easy matter without local anaesthesia. The cases described illustrate the occurrence of carcinomas of the lids, with or without accompanying nodules in the face. In some cases there had been previous treatment by cautery or "cancer-paste," which had resulted in scar tissue, and these were less satisfactory as regards cosmetic and functional results than those which had been untreated.

In all cases, however, cure of the carcinoma was complete and permanent up to date of writing.

The dosage was regulated according to the severity of the case, running from 25 mgm. to 100 mgm. for periods of from 3 hours to 33 hours for each application. In the majority of cases applications were repeated at intervals of a few months, the greatest number of applications being five, which extended over a period of about one year.

In one case of double cataract, the cataract of the side affected by carcinoma disappeared after irradiation, and that of the other eye remained unchanged.

Withers considers the radium method of treatment for carcinoma of the lids should be selected over any surgical procedure.

J. HAMILTON MCILROY.

(3) **Lancaster. W. B. (Boston). — Argyrol.** *Trans. Amer. Ophthal. Soc*, 1920. p. 151.

(3) **Lancaster's** experiments convince him that argyrol is a powerful antiseptic as tested on staphylococcus aureus in serum or in salt solution. It is effective as weak as 1 per cent. or even less and it also has bactericidal power, especially in strengths of 20 per cent. or over, but it is not a rapid bactericide.

S. S.

CORRESPONDENCE

WASHINGTON CONGRESS OF OPHTHALMOLOGY

To the Editor of THE BRITISH JOURNAL OF OPHTHALMOLOGY.

SIR,—It is announced by the Committee on Scientific Business for an International Congress on Ophthalmology to be held in Washington, D. C., April 25 to 28, 1922, that no ophthalmologists and no scientific societies of Germany or Austria have been invited to take any part in that Congress, and none will be so invited. The invitations are confined to those countries with which the United States was in diplomatic relations at the time the Committee for the Congress was organized.

EDWARD JACKSON,
Chairman, Committee on Scientific Business.

NOTES

Death

IT is with regret that we announce the death of George Thomas Stevens, at the age of eighty-nine years. To begin with he was in general practice, but at the outbreak of the Civil War in 1861 he was commissioned an assistant-surgeon in the 77th regiment New York State Volunteers. He was later made surgeon, and for two and a half years was the operating surgeon of his division. He served in all the campaigns of the Army of the Potomac, and for some time was medical inspector of the sixth corps. At the end of the war he resumed the general practice of medicine in Albany. In 1870 he was appointed Professor of Physiology and of Diseases in the Eye in the Albany Medical College, the Medical Department of Union University. In 1880 he removed to New York and confined his practice to eye work. He retained his ability to perform delicate operations into his eighty-sixth year. He was a prolific writer, taking up his army experiences, functional nervous diseases, and botany. Natural history appealed to him very strongly. His principal contribution to medical science was to be found in his contributions and investigations into anomalies of the muscles of the eye. He introduced a terminology which has been usually adopted, namely, orthophoria, heterophoria, esophoria, exophoria, hyperphoria, heterotropia, esotropia, exotropia, hypertropia, anophoria, catophoria, and declination. He introduced the standard instruments the phorometer, the tropometer, and the clinoscope. In his particular line he was a pioneer.